Thomas Jefferson National Accelerator Facility

DRAFT

INSTITUTIONAL PLAN

FY 2003 - FY 2007

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(Revision 2)

Jefferson Lab
12000 Jefferson Avenue
Newport News, Virginia 23606

Jefferson Lab is managed and operated for the U.S. Department of Energy by the Southeastern Universities Research Association (SURA) under contract DE-AC05-84ER40150.

Office of Science approval of this plan is pending. Initiatives are provided for consideration by the Department of Energy. Inclusion in this plan does not imply department approval of or intent to support an initiative.

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EXECUTIVE SUMMARY

The Thomas Jefferson National Accelerator Facility (Jefferson Lab) is the youngest of four major basic research facilities in High Energy and Nuclear Physics in the United States. It provides a scientific instrument and research opportunities that are unique in the world. Built, managed, and operated by the Southeastern Universities Research Association (SURA) for the Department of Energy (DOE), Jefferson Lab makes possible an international user community's research into how nucleons are built from quarks and gluons, and how this structure leads to the standard nucleon-based picture of the nucleus of ordinary matter. Now in its fifth year of full-scale operations, Jefferson Lab has met and exceeded original goals and specifications. Copious physics data of unprecedented precision are providing new insight into the structure of nucleons and attest to the unique beam quality. The performance of the enabling accelerator technology made Jefferson Lab a key partner in the construction of the Spallation Neutron Source. Jefferson Lab's Free Electron Laser (FEL), which is also based on this technology, and recent developments in detector technology hold high promise beyond science in defense, security, health, and manufacturing.

This Institutional Plan (FY2003 through FY2007) represents an evolutionary update, drawing on new knowledge and insights into the opportunities and challenges facing organization. The plan breaks down Jefferson Lab's scientific/technical enterprise into four program lines: nuclear (Hadronic) physics; research and development of grand instruments of science and technology for a wide range of applications including advanced computing, medical imaging, and homeland security; photon sciences and applications; and development of unique scientific/technical tools.

The scientific program at Jefferson Lab takes advantage of the confluence of theoretical achievements in the form of quantum chromo dynamics as underlying theory, advances in high speed computing, and the development and application of accelerator and detector technology that allows the cost effective production of highly polarized continuous electron beams and experimental apparatus necessary for the precision exclusive scattering measurements that are at the core of our progress in this field. An impressive body of experimental work has been completed to date. Elastic scattering and photodisintegration studies of the deuteron as well as the spin structure of nucleons (Gerasimov-Drell-Hearn (GDH) sum rule) clearly illustrate the transition from a nucleon-based to a quark-based understanding of the atomic nucleus. Precision data of the neutron electric form factor and surprising data on the ratio of electric to magnetic form factors of the proton guide the development of theoretical models. Evidence is mounting for the identification at Jefferson Lab of new excited states of the nucleon predicted by theory but heretofore unseen (calling into question our understanding of the degrees of freedom in the nucleon). A comprehensive program to measure strange form factors is about to begin.

The 12 GeV upgrade of the Continuous Electron Beam Accelerator Facility (CEBAF), recommended as a high priority by the Nuclear Science Advisory Committee (NSAC) will build on the insights and new data provided by the 6 GeV and support a substantial expansion of our research horizons including breakthrough programs in three key areas. There are, moreover, plans to upgrade the machine energy to 12 GeV. The upgrade will enable CEBAF's world-wide user community to greatly expand its research horizons, and will allow breakthrough programs to be launched in three key areas:

- The experimental observation of the powerful new force fields ("flux tubes") responsible for quark confinement, one of the most spectacular physics discoveries of the 20th century; understanding these fields is essential for understanding the force underlying the structure of the atomic nucleus;
- The measurement of the quark and gluon structure of the proton, the neutron, and other nuclear building blocks at the most basic quantum level;

- Open important new research domains in key areas already under investigation.

This program provides a unique opportunity for a major advance in carrying out the Department's and the laboratory's Nuclear Physics mission; it directly addresses the objective of understanding how nucleons are formed from quarks and gluons and how they nucleons are, in turn, bound together to form nuclei by addressing key issues in "strong" Quantum ChromoDynamics (QCD).
Drawing further on the synergistic and simultaneous development of theory and experiment, in particular the Jefferson Lab/MIT collaboration in Lattice Quantum Chromodynamics (LQCD) computing, essential questions such as quark confinement will be addressed in a definitive manner.

The underlying and enabling accelerator science and technology are Jefferson Lab core competencies: superconducting radio frequency (SRF), the formation of bright, highly polarized electron beams, and Energy Recovered Linacs (ERLs). The maintenance of these core competencies in a tight funding environment is both a challenge and a priority. Successful partnering in the Spallation Neutron Source (SNS) and our Department of Defense (DOD) funded FEL work are examples of leveraging work for others to accomplish this end. The 12 GeV Upgrade, the Rare Isotope Accelerator (RIA), and beam cooling at the Relativistic Heavy Ion Collider are examples of proposed projects that benefits this conscious cultivation of a technology. Outside Nuclear Physics both the highly anticipated linear collider and future high performance light sources would benefit from a stronger, dedicated, and non-project-specific R&D program in these areas; we are seeking funding for such a program.

Funded largely by DOD, the Jefferson Lab FEL program is an outstanding technical success. The original 1 kW infrared (IR) Demo demonstrates operationally reliable record performance, as well as energy recovery. It is currently being upgraded to 10 kW IR, 1 kW UV, and at the Navy's request, approaches to achieve 100 kW have been established. The scientific use of the facility, despite brilliant results obtained from minimal operation, is funding limited, and its full potential is yet to be realized. It is an institutional priority to address this situation.

Finally, in the area of developing scientific tools and instruments for a wide range of applications, two stand out as being significant. First, Jefferson Lab continues to develop commercial applications of its detector expertise in cancer detection and treatment, and this same technology is being explored for applications in homeland security. Second, and of great import to our central mission, is the development of computing facilities in collaboration with MIT that will, towards the end of the decade, provide tens of teraflops of computational power for LQCD calculations and other complex scientific modeling.

In order to deliver science effectively, it is incumbent on the laboratories to be managed effectively, to optimize their human and fiscal resources, to operate safely, to preserve the environment, and to ensure the security of both physical and intellectual assets. Jefferson Lab has been fortunate to be part of a welcoming community that values our presence. We will continue outreach efforts that make a difference both today and in the future by reaching our young people.

It is particularly important that in a time when so many of our national challenges – technical, medical, environmental, defense, economic – require innovation and creativity, the intellectual and scientific resources in our national laboratories contribute all they can toward addressing national priorities. This requires a vision and a practical plan for getting there. Jefferson Lab has developed a vision based on its unique expertise and facilities, and this Institutional Plan is our roadmap for realizing the full potential that is vested in Jefferson Lab.

I. LABORATORY DIRECTOR'S STATEMENT

This Draft Institutional Plan expresses our emerging vision and programmatic intent as the Thomas Jefferson Accelerator Facility (Jefferson Lab) moves to meet identified challenges and grasp new opportunities to advance our mission in fundamental research.

My highest priority is the completion of our leadership team, a team that will not only commit itself to continue the Jefferson Lab tradition of excellence but also strive for a new level of accomplishment in science, technology, and institutional management. Jefferson Lab has, and must continue to perform at the highest levels in the delivery of science of high quality and broad relevance.

The beautiful results of the Jefferson Lab program in hadronic physics show the power of the original vision and the confluence and synergy of theory, state of the art experimental equipment, forefront accelerator technology, and emerging capabilities in high performance computing. These same elements, enhanced by recent developments and advances, are at the core of our plans to maintain and strengthen JLab’s role as one of the leading international centers for the definitive study of how nucleons are built from quarks and gluons, and how this structure leads to the standard nucleon-based picture of the nucleus. At present and in the near future, this program centers on the use of the existing 6 GeV facility, a focused theory effort aimed at timely understanding and interpretation of emerging data, and early results from the JLab-MIT lattice QCD initiative. The essential step forward for the rest of the decade will be the realization of the 12 GeV Upgrade; it is motivated by outstanding science and has been endorsed by the community through the Nuclear Sciences Advisory Committee (NSAC) Long Range Planning process. Together with greatly enhanced capabilities in high performance computing, the 12 GeV Upgrade is expected to address such fundamental issues as quark confinement and quark correlations in nucleon structure. There are indications that completing our understanding of the quark-gluon structure of matter may require both higher energy fixed target and colliding beam capabilities with the highest luminosities achievable. JLab has a concept that incorporates both capabilities, at performance levels not projected anywhere else and retaining the broadest experimental flexibility.

In the support of nuclear physics, JLab has developed world-leading advanced accelerator capabilities that are unparalleled in the nation. These capabilities are currently put to use in the construction of the Spallation Neutron Source, the currently largest project of the Office of Science. They also found application in the various stages of development of the record breaking and seminal Free Electron Laser at (FEL) at Jefferson Lab. This machine first demonstrated the concept of reliable, high-power energy recovery in superconducting linacs, and thus has become the paradigm for a large number of proposed advanced accelerators. The Navy and the Air Force fund most of the Jefferson Lab FEL work, and Jefferson Lab is proud to be able to contribute in these critical times work of relevance to national security.

Jefferson Lab sees wide applicability of this rich accelerator expertise in the Office of Science and beyond for basic and applied science, for security and defense, and for manufacturing. A central challenge is to maintain these unique capabilities in times of tight funding and with slower than originally anticipated progress in the initiation of large projects. JLab is poised to work with the department and other federal agencies towards the most beneficial outcome.

Sound operations funding remains a core issue, and while this aggressive and ambitious plan discusses the outstanding benefits the Lab could provide at a generous funding level, we are aware of the need to fit into an overall fiscal framework and an overall strategic plan. Part of our vision and expectation from the laboratory leadership team is an ongoing effort to improve and increase the return in terms of science for the federal investment. Moderately increased funding and, equally important, an improved stability in the level of funding of Jefferson Lab, would actually improve the cost/benefit ratio by allowing at the margin substantial gains that uniquely contribute to the scientific and technological goals of the Office of Science.

Christoph W. Leemann, Director

II. LABORATORY CAPABILITIES IN SUPPORT OF DOE'S OBJECTIVES

DOE's OFFICE OF SCIENCE OBJECTIVES

Understand the nature of matter at the most fundamental level

Provide leading research facilities and instrumentation to expand the frontiers of natural sciences

Advance computation and simulation as critical tools in future scientific discovery

JEFFERSON LAB CAPABILITIES

Nuclear and particle physics, experimental, theoretical, and computational (simulation)

High performance computing for LQCD

Superconducting radio-frequency science & technology

Polarized electron sources

Accelerator and beam physics

Accelerator-driven light sources (FELs and synchrotron radiation sources)

Advanced detectors and data acquisition and analysis technology

2K cryogenics

Very large real time systems for process control

JEFFERSON LAB MAJOR FACILITIES

CEBAF (Superconducting Radio-Frequency Accelerator): From .05 to (currently) 6 GeV, 100 picoamps to 200 microamperes, continuous-wave electron accelerator, upgradeable to ~25 GeV. Simultaneous beams to 3 end stations with polarization exceeding 80%.

End Station A: Two high resolution magnetic spectrometers

End Station B: Large acceptance superconducting toroidal magnet system for detecting multiparticle final states (capable of handling 1 Tbyte/day)

End Station C: General purpose spectrometers and experiment-specific equipment

Superconducting Radio-Frequency Technology Facility: Superconducting accelerator cavity fabrication, surface treatment, cryomodule assembly and test, and research facilities

FEL User Facility: IR/UV Upgrade Free-electron laser designed to provide 10 kW of laser light with ps pulse length, transform-limited bandwidth, and diffraction-limited emittance

LQCD Computer: A 0.25 Tflop commodity-PC-based machine upgraded to two mutli-Tflop machines in 2005

Applied Research Center: In collaboration with local colleges/universities and the City of Newport News, share cooperative R&D laboratories in lasers, plasmas and materials

JEFFERSON LAB GOALS

Enable and conduct a physics research program of the highest scientific priority at the nuclear/particle physics interface.

Conduct research and development relevant to future grand instruments for science and technology (accelerators, detectors, and lasers).

Enable and conduct a photon science research and development program of the highest scientific priority using a variety of instruments and serving academia, industry, and the military.

Develop applications of unique scientific and technical tools for use in other areas based on JLab core competencies (e.g., special computation and instruments for life and health sciences).

Make necessary investments in the future scientific vitality of the facility.

Continue as a recognized leader in safe, secure, and environmentally sound operation.

Serve as an asset to, and an integral member of, our community.

III. LABORATORY SCIENTIFIC AND TECHNICAL VISION AND STRATEGIC PLAN

Situational Analysis

The DOE has as one of its four program lines, scientific research in support of national goals and objectives, including the development and operation of major scientific user facilities. The experimental program currently underway at Jefferson Lab fulfills a major priority of the Department's nuclear science program by providing unique, high-energy, continuous-wave (cw) polarized electron beams that support a broad range of innovative research at the forefront of nuclear physics.

Jefferson Lab's CEBAF is the only facility worldwide with the capabilities to fully explore the energy region at the transition between the regime where the standard picture of the nucleus as a group of protons and neutrons interacting through potentials is appropriate, and the regime where the quarks and gluons inside the nucleons must be explicitly included. At the high-energy end of this transition region, the essentially exact calculations of perturbative quantum chromodynamics (pQCD) provide a framework for this exploration. In the lower-energy, non-perturbative region, characteristic of normal nuclear matter, an important new "strong QCD" framework is required. Elucidating the nature of this transition region is one of the last frontiers in our understanding of ordinary matter. The importance of the experimental program at Jefferson Lab is recognized in the NSAC Long Range Plan and emphasized in recommendations both for increased operations funding and a timely realization of an upgrade to the facility.

The power of the Jefferson Lab facility is demonstrated by recent measurements of the elastic form factors of the proton and neutron that give a global snapshot of the overall spatial distribution of charge and magnetization inside these basic nuclear building blocks. This information is an essential ingredient for conventional nuclear physics. It is also providing new insights and a stringent testing ground for QCD-based theories of the nucleon, because at higher energies the decomposition of a complete set these form factors can reveal the separated spatial distributions of up-, down-, and strange-quark flavors. The Jefferson Lab program has elucidated a dramatic, unexpected, difference between the charge and magnetization distribution of the proton, and has provided the first detailed information on the charge distributions of the neutron. In addition, a rich, unprecedented, electroweak program is in progress to resolve the question of how strange quarks cooperate in constructing the proton.

There is real delight and excitement in the over 2100-member user community about the proven capabilities of Jefferson Lab's CEBAF accelerator and the data emerging from the current experimental program. However, these scientists can also now see into the future well enough to know that a more powerful machine will be required to continue the job of understanding the fundamental quark structure of matter, and they have been a driving force in obtaining support in the wider scientific community for an upgrade of the CEBAF accelerator through the NSAC Long Range Plan process. This upgrade will allow users to complete the picture we have begun to fill in with our current program and will allow access to new and compelling science not envisioned at the time of CEBAF's construction. It is gratifying that this upgrade has been included as one of the main recommendations of the Long Range Plan.

As a program-dedicated Laboratory, basic research is our primary mission, and, as a user facility, Jefferson Lab strives to provide an environment conducive to world-class research. However, it is critical that we maintain an appropriate balance between conducting our current program and making the investments that are necessary to ensure the future scientific vitality of Jefferson Lab. We are pleased that the NSAC Long Range Planning group included as its first recommendation the need to find the additional funding necessary to allow the nation's unique major research facilities, including Jefferson Lab, to maintain their forefront position. We also are gratified that the requested President's Budget showed an increase in funding for Jefferson Lab of $5.3M. We are hopeful that in addition to other post 9/11 priorities, this represents a trend that recognizes the importance of our nation's R&D enterprise to our national security. Now more than ever, it is critical that the investment made by the nation in Jefferson Lab and its unique capabilities is used to its fullest advantage.

Besides Jefferson Lab's leading role in Nuclear Physics and in accelerator-related technologies, other competencies have emerged. Jefferson Lab's FEL, an outgrowth of our expertise in SRF and accelerator technologies, has great potential, not only as a testbed for future accelerators but as a tool for basic and applied materials research. Jefferson Lab's detector technology has led to the development of tools for medical imaging and security screening. The same scale of computing needed for LQCD calculations may have broader application as well. In light of these emerging capabilities and potential, and the urgent nature of the challenges facing our national science enterprise, Jefferson Lab developed a vision and strategic plan that optimizes our worldwide unique capabilities and facilities. We have formed a Science Policy Advisory Group to help the Director identify obstacles and opportunities as we pursue a vision based on our core competencies, focused on areas where we can make a unique and singular contribution. This vision includes four primary programmatic lines as well as exemplary institutional management and maps out a dynamic future for Jefferson Lab that holds great promise for the Laboratory and great potential for customers and stakeholders.

Unique capabilities resulting from the federal investments in Jefferson Lab provide a basis for a strategic plan that increases Jefferson Lab's influence in the scientific community and increases its impact on national priorities.

Vision and Strategic Goals

In light of the situational analysis summarized above and the core competencies and facilities resident at Jefferson Lab, four programmatic elements and research and development areas have been identified for Jefferson Lab:

<u>Nuclear Physics</u>
To continue progress and expand investigations of nucleon and nuclear structure, the origins of the nucleon-nucleon forces, the quark-gluon structure of nucleons and nuclei, and the origins of quark confinement require the present 6 GeV and the forthcoming 12 GeV capability. Looking further into the future, the research program may require 24 GeV external beam capability and/or an electron-ion collider (EIC). JLab has developed the most advanced concepts for a combined high luminosity collider and fixed target facility. Together with a strong effort in theory and lattice QCD JLab is poised to remain the world center for the elucidation of the quark-gluon structure of strongly interacting matter.

<u>Research and Development of Grand Instruments of Science and Technology</u>
Not only nuclear physics but also other sciences and technologies require constant innovation in the science and technology of accelerators, detectors, lasers, light sources, and other major research instruments. Jefferson Lab's core competencies uniquely position us to be a national and worldwide resource and play a lead role in the development of new and novel accelerators for use in basic and applied science as well as for industrial and defense applications.

<u>Photon Sciences and Applications</u>
Scientific investigations in physics, biology, chemistry, and other sciences, as well as technological applications in fields including advanced materials and national defense, require photons from our FELs, the High Energy Lithography Source (HELIOS) synchrotron, and envisioned future Jefferson Lab light sources.

<u>Development of Unique Scientific/Technical Tools</u>.
Nuclear physics and other sciences and technologies continually require new advanced computational physics tools such as LQCD and large-scale computing for nuclear physics, instrumentation for biomedicine and for nuclear medicine imaging, and the variety of smaller technological innovations that can be spun off from activities at Jefferson Lab.

In addition to these programmatic areas, JLab pursues institutional management goals that:

1. Leverage resources to support national goals and objectives.

2. Prepare a broadly educated next generation of scientists and engineers, including traditionally underrepresented populations, for a globally competitive research environment and economy.

3. Contribute to public science literacy and appreciation through community outreach and involvement as well as motivational math and science educational programs for young students.

4. Maintain and further develop a world-class workforce.

5. Lead responsibly by conducting environmentally sound, safe, and secure operations.

Strategic Plan

At the summary level, Jefferson Lab's Strategic Plan includes the following elements:

- As the highest priority, to run its internationally preeminent nuclear physics research program in balance with key investments needed for the scientific future of the Laboratory.

- To begin the 12 GeV upgrade as warranted by scientific priorities and endorsed by the DOE/NSF (National Science Foundation) Nuclear Science Advisory Committee Long Range Planning Group.

- Perform LQCD calculations to assist and guide 6 GeV and 12 GeV experimental programs.

- Ultimately, to upgrade the accelerator to 24 GeV. Build and operate an EIC to extend still further the scientific reach of the experimental program.

- To accomplish—and to build user laboratory infrastructure and user participation for—the 10 kW FEL upgrade, including incorporation of capability for 1 kW UV, THz radiation, and Compton X-rays, and later, to undertake the 100 kW FEL upgrade.

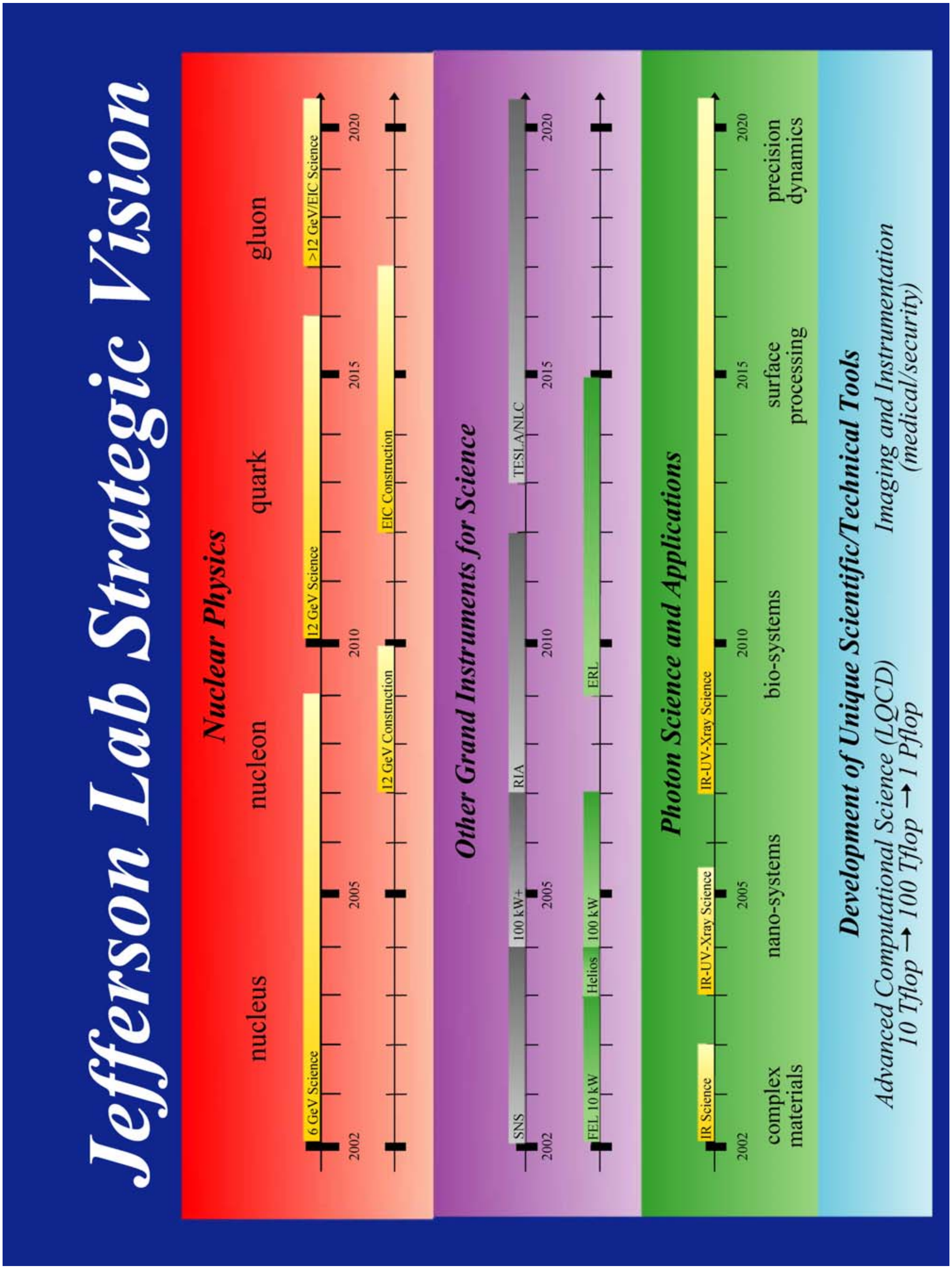
- To install and operate—and to build user laboratory infrastructure and user participation for—the HELIOS synchrotron, including IR and soft X-ray beam lines, the addition of superconducting undulators, and the synchronization of HELIOS to the FEL for dynamics experiments.

- In the five-year term, to develop first- and second-generation high-resolution, high-sensitivity, single-photon small-animal imagers, a dual-modality breast imager, and compact, portable detectors, followed in the ten-year term by high-sensitivity nuclear medicine detectors with submillimeter resolution, organ-specific detectors for patient imaging, and detectors for non-nuclear biomedical imaging, with projects aligned with the U.S. Genomes to Life Program and other initiatives.

- To participate in partnerships mutually beneficial to DOE, Jefferson Lab, the region, and the nation.

- To engage our diverse stakeholders and customers in discussions of their interests and needs, including providing security and preservation of environment, health, and safety.

In light of Jefferson Lab's capabilities and core competencies, we hope to develop initiatives that will create a dynamic and responsive portfolio to address challenges and opportunities relevant to DOE's mission.


Jefferson Lab Strategic Vision
Nuclear Physics
nucleus
nucleon
quark
gluon
6 GeV Science
12 GeV Science
>12 GeV/EIC Science
12 GeV Construction
EIC Construction
2002
2005
2010
2015
2020
Other Grand Instruments for Science
SNS
100 kW+
RIA
TESLA/NLC
FEL 10 kW
Helios
100 kW
ERL
Photon Science and Applications
IR Science
IR-UV-Xray Science
IR-UV-Xray Science
complex materials
nano-systems
bio-systems
surface processing
precision dynamics
Development of Unique Scientific/Technical Tools
Advanced Computational Science (LQCD)
10 Tflop → 100 Tflop → 1 Pflop
Imaging and Instrumentation
(medical/security)

IV. RESOURCE PROJECTIONS

Table IV-1 reflects Jefferson Lab's key performance goals, FY2001 actual funding, FY2002 projected funding, and FY2003 through FY2007 requirements funding. We show Nuclear Physics funding separately for operating, capital equipment, and GPP/AIP (General Plant Project/Accelerator Improvement Program), LQCD, RIA, and 12 GeV. Priorities emerging in each fiscal year are likely to dictate some variation in the allocation from that projected in the table to optimize mission productivity.

Other major resources include funding provided for the FEL and the Spallation Neutron Source (SNS). For the SNS project, Jefferson Lab is the lead partner for the refrigeration system and the cryomodules. With $16.4M of funding provided by the Office of Naval Research (ONR) in FY2000-2002, Jefferson Lab is designing and fabricating an upgrade to the IR Demo FEL that will increase the optical power output in the infrared to over 10 kW when the upgrade is commissioned in FY2003. The Air Force Research Laboratories provided $4.3M of funding in FY2001-2002 to add 1 kW of UV capabilities to the FEL Facility.

Tables IV-1 and IV-2 raise two important issues with regard to the funding of the Laboratory and its users. First, the Nuclear Physics (NP) operations funding we receive is significantly below the level necessary for optimum scientific productivity. In FY2002, the Nuclear Physics funding received was $1.7M less than inflation above FY2001. Table IV-1 details the FY2003 NP President's Budget of $79.1M. The FY2004 NP requirements budget reflects an increment of $26.6M (in AY$) above the FY2003 NP President's Budget and provides for increases as follows:

- $2.7M for inflation at 3.5%.
- $0.8M for SNS overhead loss.
- $0.8M for improved running.
- $1.6M for SRF core competency.
- $3.2M for maintenance of conventional facilities and experimental equipment.
- $2.1M for additional 5 weeks of running.
- $1.1M for additional research staff.
- $2.4M for Advanced SRF R&D.
- $1.6M for Advanced Accelerator.
- $4.4M for facilities infrastructure.
- $1.2M for LQCD support.
- $3.7M for 12 GeV.
- $1M for RIA support.

The increment in operating funds will permit us to increase the weeks of accelerator operating from 28 weeks in FY2002 to 35 weeks in FY2004, and a resulting increase in delivered physics research operations (weeks of research operations when both beam and experimental equipment are operating simultaneously, a key metric which also includes the productivity resulting from multiple hall operation) from 37 weeks in FY2002 to 53.6 weeks in FY2004 and to raise the accelerator operations efficiency and experiment multiplicity by an amount that will increase the scientific productivity by 43%.

The second important issue is related to the current level of staffing (Table IV-2) at the Laboratory, which was established by DOE based on NSAC guidance that assumed strong funding of Jefferson Lab user groups so that they could provide on-site effort for installation and operation of their experiments and for maintenance of the equipment they built. Most of our user groups do not receive sufficient funding to provide this assumed and very necessary support function. This situation must be rectified or long-term operational reliability and our ability to continue to mount important new physics experiments will suffer.

Table IV-3 summarizes the results of our contract performance measures for FY2000 and FY2001.

Table IV-1
Jefferson Lab Funding and Key Performance Goals

(Actual Year $ in Millions - BA)	FY2001 (Actual)	FY2002 (Projected)	FY2003 (PresBud)	FY2003 (Req)	FY2004 (Req)	FY2005 (Req)	FY2006 (Req)	FY2007 (Req)
SCHEDULED ACCEL OPS FOR NP (wks)	*33.7*	*28.0*	*30.0*	*35.0*	*35.0*	*35.0*	*35.0*	*35.0*
BEAM AVAILABILITY (%) [1]	*68.0*	*70.0*	*70.0*	*73.0*	*75.0*	*75.0*	*75.0*	*75.0*
EQUIP AVAILABILITY (%)	*84.1*	*80.7*	*80.7*	*82.0*	*85.0*	*85.0*	*85.0*	*85.0*
EXPERIMENT MULTIPLICITY [2]	*2.8*	*2.5*	*2.5*	*2.5*	*2.5*	*2.5*	*2.5*	*2.5*
DELIVERED PHYSICS RESEARCH OPS (wks) [3]	*51.5*	*37.0*	*40.7*	*50.3*	*53.6*	*53.6*	*53.6*	*53.6*
FUNDING								
Office of Science								
Nuclear Physics								
Operating	65.0	66.0	71.3	81.5	87.1	89.4	92.7	95.3
Capital Equipment	5.6	5.9	6.1	6.1	7.1	7.3	7.6	7.9
GPP [4]	1.0	.6	.4	.8	4.8	3.6	4.4	1.5
AIP	1.3	1.3	.8	.8	.8	3.4	3.5	3.6
LQCD				.8	1.2	2.0	2.0	2.0
RIA	.4	.2		.5	1.0	1.0	1.0	3.0
12 GeV TPC (above redirect)			.5	.5	3.7	7.3	24.5	40.1
Subtotal Nuclear Physics	73.3	74.0	79.1	91.0	105.7	114.0	135.7	153.4
SciDAC – LQCD/PPDG	.8	.7		.9	1.2	2.0	2.0	2.0
Computational & Tech Research	.1	.1						
Biological & Environ. Research	.6	.5		.6	.7	.7	.7	.7
Prog Direction – Undergrad Fellowship	.1	.1						
Facil Support – CEBAF Ctr Additions			1.5	1.5	4.6	5.9	7.0	6.5
Facil Support – Test Lab Rehab								.8
Total Office of Science	74.9	75.4	80.6	94.0	112.2	122.6	145.4	163.4
Office of Management, Budget & Eval								
SNS	22.4	22.6	5.5	5.5	4.0	.1	.5	.5
FEL (NAVY, AF, JTO)	7.6	3.6	6.5	6.5	11.0	11.0	11.0	11.0
Cost of Reimbursable Work	.1							
Assist. Sec. for Energy Eff.	.5							
Office of Security & Emergency Ops	.8	1.0	1.0	1.1	1.1	1.2	1.2	1.3
Light Source Funding					2.7	3.0	5.0	10.0
Commonwealth of Virginia [6]	1.4	1.4	5.1	5.1	2.0	1.4	1.4	1.4
TOTAL FUNDING	**107.7**	**104.0**	**98.7**	**112.2**	**133.0**	**139.3**	**164.5**	**187.6**

1 Availability is averaged over all running experiments
2 Multiplicity indicates expected # of experiments running at the average
3 Number of weeks of beam summed over all targets
4 GPP Funding includes Strategic Facilities Plan
5 Includes R&D, Pre-Ops, and Ops above redirected NP
6 Includes HELIOS funding starting in FY03 requirements

Table IV-2
Jefferson Lab Personnel Summary (Average)

Full-Time Equivalent (FTE)	FY2001 (Actual)	FY2002 (Projected)	FY2003 (Pres Bud)	FY2003 (Req)	FY2004 (Req)	FY2005 (Req)	FY2006 (Req)	FY2007 (Req)
Office of Science (excluding SNS)	436	446	453	480	551	580	588	588
SNS	61	58	50	50	38	1	5	10
Safeguards and Security	3	5	5	5	5	5	5	5
FEL (NAVY, AF, JTO)	27	36	43	43	40	38	36	36
Light Source					3	5	7	7
Commonwealth of Virginia	17	16	17	26	24	17	17	17
Indirect	110	120	120	125	125	125	127	127
TOTAL LAB PERSONNEL	**654**	**681**	**688**	**729**	**786**	**771**	**785**	**790**

Includes all full-time staff, part-time staff, contract labor and joint/bridged positions

Table IV-3
FY2000 and FY2001 Contract Performance Measure Results

Performance Measure	Points Earned 2000	Points Earned 2001	Points Available
Outstanding Science and Technology *Produce outstanding science and technology.*	**280.5**	**285.1**	**300**
Reliable Operations *Achieve reliable performance of the accelerator and detectors at required specifications to ensure the scientific success of the laboratory.*	**248.5**	**245.7**	**250**
Scientific and Technical Manpower *Contribute to the education and training of the future scientific/technical work force for the nation, emphasizing meaningful, unique research experiences at the forefront in its areas of physics*	**73.0**	**74.0**	**75**
Corporate Citizenship *Serve the public and the national interest in important areas where Jefferson Lab has special competencies that are mission related.*	**73.7**	**74.1**	**75**
Quality Performance in EH&S *Protect workers, the public and the environment, adhere to the ALARA concept, and comply with laws, regulations, statutory requirements, and appropriate national initiatives (recycling, waste reduction, etc.) at lowest reasonable cost.*	**97.1**	**96.9**	**100**
Business and Administrative Practices *Maintain effective and efficient business and administrative practices at Jefferson Lab.*	**90.6**	**93.5**	**100**
Responsible Institutional Management *Manage and operate Jefferson Lab in accordance with generally accepted quality management principles so as to achieve its mission goals in a cost effective manner while satisfying its customers and providing a culture which builds trust and facilitates continuous improvement in all areas of the institution.*	**93.0**	**93.0**	**100**
Spallation Neutron Source (SNS) *Contribute effectively to the successful design and construction of the SNS at ORNL by meeting project obligations on schedule.*	**N/A**	**27.9**	**30***
Total	**956.5**	**990.2**	**1030**

* SNS performance measure added in FY2001; total points available in FY2000 was 1000

V. SUMMARY OF MAJOR PROGRAM INITIATIVES

The following major program initiatives are provided for consideration by the DOE. Inclusion in this plan does not imply DOE approval of or intent to implement an initiative.

1. 5-YEAR PLANNING

A. Increasing the energy of CEBAF to 12 GeV

The physics opportunities associated with a systematic energy upgrade of CEBAF have been endorsed in the new (April 2001) NSAC Long Range Plan, which states as one of the principal recommendations: "We strongly recommend the upgrade of CEBAF at Jefferson Lab to 12 GeV as soon as possible. The 12 GeV upgrade of the unique CEBAF facility is critical for our continued leadership in the experimental study of hadronic matter. This upgrade will provide new insights into the structure of the nucleon, the transition between the hadronic and quark/gluon description of matter, and the nature of quark confinement." NSAC further underscored the importance of the upgrade by noting that "we should emphasize that smaller initiatives – even medium size initiatives such as the Jefferson Lab Upgrade – should be accommodated within a constant effort budget."

The hadronic physics community has recognized the advantages of the upgrade for many years. It was first considered and endorsed by the larger nuclear physics community in the 1996 NSAC Long Range Plan. This endorsement was reaffirmed by the NSAC subcommittee on "Scientific Opportunities and Funding Priorities for the DOE Medium Energy Nuclear Physics Program," chaired by J. Symons, in its September 1998 report. The scientific opportunities supported by the energy upgrade also feature prominently in the report "Nuclear Physics: The Core of Matter, the Fuel of Stars," issued by the National Academy of Sciences' (NAS) Committee on Nuclear Physics chaired by J. Schiffer as part of the decadal NAS/NRC (Nuclear Regulatory Commission) survey series *Physics in a New Era*.

Based on those early endorsements, and with the support of DOE, we began the first phase of the energy upgrade shortly after commencing full physics operation of the accelerator. This first step is nearly complete, and we have delivered physics quality beams with energies of up to 5.8 GeV for extended periods. It was accomplished without the addition of any major new components. The maximum energy available at constant cryogenic consumption from the existing accelerator was extended through *in situ* processing of the superconducting cavities and peripherals and the development of a better understanding (and consequently relaxing) of the operational limits on the accelerator structures.

This effort has had two desirable outcomes: much improved availability of the accelerator for 4 GeV operation, and the capacity to run at energies close to 6 GeV with acceptable reliability for selected high-priority experiments. 5.8 GeV beam has been consistently delivered for physics experiments, and we have reached 6 GeV in test runs. As the energy is increased, the frequency of short (tens of seconds) beam interruptions increases, affecting availability. As work to remedy this situation progresses, we expect to reach a full availability at 6 GeV in FY2003. Approximately one-fourth of the approved physics program needs this increased energy capability. It permits access to higher momentum transfers (corresponding to improved spatial resolution in the nucleus) and to higher excitation energies, and provides enhanced counting rates for many experiments that could have run at 4 GeV.

The second stage of the upgrade will raise the maximum energy available to 12 GeV. This upgrade will strengthen Nuclear Physics in many ways, guaranteeing the continuation of our international leadership in a field that is rapidly becoming one of the most interesting in all of science. The proposed upgrade is being driven by three compelling physics opportunities; it will:

1. Allow experimenters to discover evidence for the powerful new force fields (which form into the so-called "flux tubes") responsible for quark confinement, one of the most spectacular physics discoveries of the 20th

century; understanding these fields is essential for understanding the force underlying the structure of the atomic nucleus.

2. Have the energy, intensity and time structure necessary to map out the quark and gluon structure of nuclear building blocks at the most basic quantum level.

3. Open up for the scientists using CEBAF major extensions of campaigns begun at 4 GeV, allowing many key scientific questions to be answered with finality:

   - At what energy does the force between two quarks switch from being confinement-generated to a typical gluon-generated force?
   - Is "color transparency" (the predicted absence of forces between quarks and nuclear matter if the quarks are "bundled" into special states with zero net strong charge and very small charged moments) real?
   - What is the underlying origin of the nuclear force as viewed at the level of quarks and color force fields?
   - Are the strong correlations between the motion of protons and neutrons in large nuclei that have been assumed for decades to explain their properties really there?
   - How are non-zero quark masses generated spontaneously from zero quark masses, and how do these masses affect the properties of the nuclear building blocks?

Second to energy, and apart from the ongoing requirement for highly polarized beams, the most important beam requirement for physics research is high duty factor (ideally continuous wave (CW)) operation. With regard to beam current, research needs are met by maintaining constant beam power at 1 MW; i.e. reducing the beam current as beam energy increases. The meson spectroscopy program, which will use one of the three output beams, is in fact adequately served by a few μA.

The upgrade project has an estimated cost range of $170M–250M (AY$) over the years FY2003–2010. In addition to funding from DOE/NP, we are seeking resources from other agencies and foreign collaborators. The project will double the beam energy by adding ten new cryomodules to the accelerator placed in the existing free spaces in the linacs. In addition, the helium refrigerator capacity must roughly double, some of the beam recirculation and transport magnets must be upgraded and a few of them must be replaced. The experimental equipment in each of the three Halls would be enhanced, and a fourth Hall would be added to house the major new detector needed for investigation of quark confinement.

The main development and prototyping thrust is in the areas of cryomodules. The dual objective is to increase accelerating gradient and Q value to provide increased energy gain within the envelope of doubled cryogenic capacity. The newest cryomodules, i.e. those built for the FEL, show a significant performance improvement over those presently installed in CEBAF. Further improvements are anticipated in the next generation that will use longer accelerating structures (while retaining the same overall cryomodule length), improved surface treatments, and better assembly procedures. A series of prototypes will be built to demonstrate the required performance. In addition, control alternatives will be explored that have the potential for significant reductions in the required RF power for the accelerating structures.

B. Centers of Excellence

Institute for Superconducting Radiofrequency Science and Technology

Jefferson Lab's core strength and competency in R&D and large-scale application of superconducting RF in its facilities are recognized internationally. Not only has the application of SRF resulted in an accelerator where performance has greatly exceeded design and is continually improving, it has also enabled the development of a second major facility at the

Laboratory, the FEL. SRF is also being applied to, or considered for, an increasing number of facilities nationally and worldwide (RIA, TeV – Energy Superconducting Linear Accelerator (TESLA), ERLs, etc.). Because of its outstanding combination of expertise, experience, and facilities, Jefferson Lab is in a unique position to contribute to a host of future accelerator projects by remaining at the cutting edge of SRF science and technology. While some of the projects that are contemplated require only modest improvements of SRF technology, others will require radical new approaches and breakthroughs in material science as well as accelerator structures design and control.

SRF is not a stand-alone discipline but a multi-disciplinary scientific activity that includes solid state physics, surface science, low temperature physics, electromagnetism, radio frequency and microwave, feedback and control systems, beam-rf interactions, and vacuum science, as well as mechanical engineering and cryogenics. The greatest advances in the application of SRF to accelerators will require a close collaboration and integration between these various areas of expertise.

In order to further maintain and enhance its primary core competency in the area of superconducting radiofrequency cavity and linear accelerator technology, and in order to give SRF the level of visibility commensurate with its importance to the Laboratory and the accelerator community, Jefferson Lab has created a vertically integrated central professional research, development, and production center, the Institute for Superconducting Radiofrequency Science and Technology. The institute incorporates the associated disciplines of radiofrequency power and its control, research and development of novel cavities, surface science studies, cryogenics and cryomodule production capability, and electromagnetic and particle beam driven test facilities. It will have Jefferson Lab's SRF Test Lab and the FEL beam facilities as its primary test facilities and is chartered with staying abreast of the production of state-of-the-art SRF cryomodules for current and possible future accelerator projects such as the SNS, RIA, the 12 GeV CEBAF energy upgrade, future linear collider, etc. Simultaneously with enhancing production capabilities, the institute is chartered with taking bold steps in its R&D effort pushing the SRF potential to its fundamental limits and pointing to further technological breakthroughs. Concurrent with the programmatic goals of production and R&D, the institute is to establish its own information management architecture to ensure archiving of various procedures and SRF related data, create an educational training and mentorship program in partnership with senior laboratory management and universities worldwide, participate in technology transfer and other SRF applications, and maintain its globally competitive status by establishing collaboration and partnerships with institutes worldwide. It will serve as a training ground for the next generation of SRF physicists through support of students, postdoctoral fellows, and visiting scientists.

Center for Advanced Studies of Accelerators

The accelerator physics community at Jefferson Lab is a precious resource being shared and called upon by various departments in the Laboratory – the CEBAF and FEL operations, SRF physics, and beam measurements and control. At the same time, this group is responsible for aggressively promoting new initiatives at the Laboratory based upon its core competencies of beam and radiation physics, SRF science and technology and various particle source technologies.

Our accelerator physicists have contributed to the success of the CEBAF accelerator and the FEL facilities and have initiated a great many new ideas in the field that are being rapidly recognized by the international community. Examples of these new initiatives are: the 12 GeV and 24 GeV upgrade projects, a possible high-luminosity electron-ion collider facility for nuclear physics, the principle and technical demonstration of ERLs and their application as electron coolers in possible future electron-heavy ion collider facilities such as the e-RHIC (Relativistic Heavy Ion Collider) that is being considered at Brookhaven National Laboratory (BNL), future light sources, etc.

In order to further enhance the primary competency of Jefferson Lab in accelerator science and technology and to bring it to the level of visibility commensurate with its importance to the Laboratory and the community at large, Jefferson Lab has created an integrated center of excellence in accelerator science, CASA. The center will incorporate all related disciplines in particle and photon beams – dynamics, optics, sources, instabilities and their control, various incoherent and coherent radiation phenomena and numerical simulation of particle and light beams. In partnership with the SRF institute and other departments in the Laboratory, the center has the charter of not only supporting on-going activities at the Laboratory, but to look after and promote boldly future options in sub-atomic physics.

C. Light Source Program Development

Basic Research with Light Sources

A basic research program using light sources has been under development since 1999 to diversify Jefferson Lab from the exclusively nuclear physics domain to incorporate multi-disciplinary, next-generation, light source research activities. These emerging research programs are allocated use of the FEL on the basis of advice from a Program Advisory Committee (PAC). With the FEL Facility upgrade in FY2002, attention is being paid to the science identified in the October 2000 workshop "Scientific Frontiers with Accelerator-Based Lasers," which guide the evolution of the FEL into a comprehensive user facility for basic and applied research with light.

Extended Capability in the FEL User Facility

By FY2004 the present (FY2000-2002) upgrades of the FEL described in Chapter VI are scheduled to be complete and operational. These upgrades will provide powers above 10 kW in the mid infrared (2-14 microns) and approximately 2 kW in the visible and ultraviolet wavelengths extending to 300 nm. In addition, we expect to incorporate extended wavelength agility by adding broad band mirrors in the optical cavities; and options for increased flexibility in the laser time structure by adding hardware for single and multiple pulse streams with pulse energies varying from the millijoule to microjoule range.

Extension to the Terahertz Regime

The FEL Facility currently is capable of providing an intense source (>1W/cm^{-1}) of partially coherent long wavelength (terahertz) radiation by extraction of the synchrotron radiation from the energy recovery bending magnets. There is significant scientific and technical interest in terahertz radiation for solid-state physics, biology and non-destructive imaging of materials with high depth of field and high contrast.

Extension to the X-ray Regime

The FEL Facility also will provide X-ray radiation using two sources that are being incorporated into the Facility during the FEL Upgrade period. The IR Demo FEL produced a source of high flux (~10^8 photons/s), ultra short pulse (300fs) X-rays (in the 5-40 keV range) by Compton scattering of the circulating IR laser radiation with the input electron beam. The FEL Upgrade will provide a 10 – 50x improvement in brightness and an increased energy range to above 400 keV. Because the Compton X-rays are synchronized with the FEL light, two color experiments are possible (also known as pump-probe experiments) where one color of light is used to initiate a chemical or physical reaction and the synchronized second color is used to follow the progress of the reaction with sub-picosecond time resolution.

High Energy Lithography Source (HELIOS) Compact Synchrotron X-ray Source

A second option for providing X-rays to the FEL Facility was enabled by the donation by one of Jefferson Lab's industrial partners of the HELIOS compact, superconducting synchrotron to SURA in November of 2000. HELIOS is a high current (800 mA), 700 MeV storage ring that provides X-rays peaking at keV (1 nm wavelength) at intensities greater than the currently operating second-generation synchrotron light sources. This source of X-rays also can be synchronized with the FEL pulses in the User Facility. Jefferson Lab plans to have the HELIOS storage ring installed and re-commissioned in a new building annex to the FEL Facility by 2004. Depending on funding initiative currently proposed by Virginia's Governor Warner, collaborations are in place with Virginia's research universities for HELIOS user activities involving X-ray diffraction for biomolecules, lithography for nanostructures, and multi-wavelength spectroscopy.

Next Generation X-Ray Source Development

Jefferson Lab's success with the IR Demo FEL demonstrated an efficient means of producing high average power and high brightness light for the R&D community. Jefferson Lab is uniquely positioned to design and implement a next generation X-ray source based on SRF driven energy recovered linacs. A world class X-ray source could be incorporated on the Jefferson Lab site, or partner-location in the 2006-2009 timeframe, taking full advantage of the FEL/HELIOS user community and the Laboratory's core competencies in SRF, electron source and accelerator technology.

Higher Power FEL Upgrades (100 kW)

One of the primary attractions of the configuration of the Jefferson Lab FEL is the affordability of power scaling. The 10 kW FEL Upgrade will provide ten times more optical power for approximately twice the capital investment compared to the original 1 kW Demo FEL; thus the net cost of providing light is reduced by approximately a factor of five. This favorable power scaling continues as this type of FEL is scaled in power to the 100 kW range and beyond. Industrial stakeholders in the FEL program and the defense community have interests in pushing FEL technology beyond 10 kW. For industrial applications, studies by our Laser Processing Consortium (LPC) partners indicate that high value-added processing such as micro fabrication is commercially attractive at the 10 kW level, and at the 100 kW level, high volume processes such as surface modification of metals and polymers become attractive.

The defense community has made large R&D investments over the last three decades in high-energy lasers for directed energy applications. Only an FEL offers the option of tunability, short-pulse time structures, and all electric drive. Until the FEL Demo device, FELs had been written off as an option for directed energy because of the lack of a development path to high average power. The Navy continues to be an important stakeholder for the FEL program because of the ability to tune IR FEL radiation to the windows in the atmospheric spectrum where there is minimal absorption. Jefferson Lab expects to continue to partner with the ONR and the Naval Sea Systems Command in the development of FEL technology beyond the 10 kW range of the current FEL Upgrade.

In response to the interest of the Navy and our industrial partners, we have proposed point designs for several 100 kW versions of the IR Demo FEL that could be initiated as construction projects shortly after we complete benchmarking the performance of the 10 kW IR FEL Upgrade project in FY2003. One option involves relatively straight-forward and modest hardware upgrades to the 10 kW device: (1) increasing the injector; (2) replacement of the first two FEL cryomodules with CEBAF energy upgrade modules; and (3) increased power handling capability for the IR optical cavity mirrors and energy recovery dump. The highest power levels would be of interest for materials damage, materials processing, and gas dynamics applications.

The second option for a 100 kW FEL involves a stand-alone device where all hardware is optimized for the most cost effective production and handling of 100 mA and higher accelerator currents. This would involve the use of lower frequency SRF cavities and RF systems such as currently being developed at Jefferson Lab and Los Alamos National Laboratory for DOE's Spallation Neutron Source at Oak Ridge National Laboratory. This option offers the opportunity to customize a 100 kW or higher power facility for industrial, scientific or defense applications. Depending on expected continuing development of the brightness of the Jefferson Lab photocathode electron sources, a 30-40 kW UV FEL could be incorporated into either higher power IR FEL system to expand both the scientific and industrial utility.

D. Advanced Computational Science: Lattice Quantum Chromodynamics (LQCD)

A full realization of the scientific benefits of the Laboratory's mission to explore the quark and gluon structure of the nucleus requires extensive theoretical work. A major new theory initiative in support of the nuclear physics program is the development of advanced computational techniques to solve Quantum Chromodynamics numerically in the "strong" regime that is appropriate for understanding nucleon structure. Jefferson Lab is a key participant in the National Computational Infrastructure for Lattice Gauge Theory, the DOE SciDAC project that brings together theorists, computer scientists, and engineers to tackle demanding quantum chromodynamics calculations. This collaboration is making significant progress in improving the software used in these calculations and is poised to begin tera-scale simulations of QCD.

The importance of this work is reflected in the NSAC April 2002 Long Range Plan, Opportunities for Science:

"Advances in computational physics and computer technology represent great opportunities…To exploit these opportunities, dedicated facilities must be developed with world-leading computational capabilities for nuclear physics research.

Lattice QCD is crucial for answering fundamental questions in strong-interaction physics, and it is widely recognized that definitive lattice QCD calculations require multi-teraflops resources—resources now available at reasonable cost. In addition, successful nuclear physics programs at Jefferson Lab and RHIC urgently need to make connection to QCD. An aggressive and dedicated effort is needed for the U.S. to regain a competitive edge—an edge that has been lost to Japan and Europe—in using lattice QCD to understand hadronic physics. The nuclear science component of an internationally competitive lattice effort requires dedicated facilities providing sustained performance of 0.5 teraflops by 2002, growing to 15 teraflops by 2005."

Consistent with this, the National Lattice QCD Executive Committee, which oversees the LQCD SciDAC activity, has endorsed a plan for deploying, by FY2006, a distributed multi-terascale computing capability which includes 8 teraflop/s (10^{12} floating point operations per second) of computing at Jefferson Lab, and a comparable capacity at Fermi National Accelerator Laboratory (FNAL) and BNL.

Both Jefferson Lab and the High Energy Physics lattice effort at FNAL have adopted a cost optimized commodity computing model based upon large clusters of inexpensive nodes connected by high speed cluster interconnects. As part of this optimization, Jefferson Lab has led the effort to specify and implement an application specific messaging interface and library to facilitate highly overlapped computation and communication. Additional optimizations of low-level linear algebra routines are now underway.

In FY2002, a $0.9M test bed of scale 0.25 teraflop/s will be deployed, partially funded by the SciDAC program. During FY2003-2006, the Laboratory's aggregate capacity is planned to grow to 8 teraflops, and continue to grow thereafter to keep pace with demands. During this timeframe, planned funding for state-of-the-art lattice calculations at Jefferson Lab will grow from $1.2M/year in 2003 (including both SciDAC and base funding) to roughly $4M in 2005 and 2006 (as the first terascale clusters are deployed) and then average roughly $4M/year, including all upgrade and operating costs. Doubling this budget to at least $8M would provide a substantial enhancement of the scientific reward.

2. LONG RANGE PLANNING

A. CEBAF Beyond 12 GeV

Studies by Jefferson Lab users and by physicists associated with the Electron Laboratory for Europe (ELFE) project have established that there is a strong physics case for constructing a CEBAF-like accelerator with energies in the 20-30 GeV range. In parallel, there have been a series of studies investigating the scientific potential of an EIC operating in the 30-100 GeV center-of-mass energy range and an electron-heavy ion collider operating in the 100 GeV center of mass range. We expect that over the next five years the scientific motivations for these different possibilities and the technical details of their realization will be developed more fully, permitting the community to optimize its choice for the next generation facility.

With the R&D described in Section V.1.A. above, the total cost of upgrading CEBAF to an energy of ~24 GeV and providing appropriate detectors for the physics experiments such a machine could support would be a fraction of the cost for a green site machine such as ELFE. The cryomodule developments that are proposed should make it possible to build such a machine in the existing CEBAF tunnel in the next decade, since replacing the remaining original cryomodules in the linacs would lead to the required installed capacity of 24 GeV.

Related R&D also is directly relevant to understanding the accelerator physics and cost issues associated with the construction of a polarized EIC on the CEBAF site. In this case, the linac tunnels would be used to house a one-pass, high average current (~250 mA) electron accelerator with output energy of order 5-6 GeV. This beam would be collided with protons and other light ions produced using a second accelerator to be added to the site, and then an out-of-phase pass would recover the energy of the bulk of the electron beam through the accelerator in a manner analogous to our FEL facility. R&D on energy recovered linacs and high-brightness electron sources needed for this facility is also of interest for beam cooling at RHIC and synchrotron X-ray sources under consideration at Cornell and elsewhere. Because the infrastructure for the electron accelerator is already in place (and many additional elements would be put in place by our planned 12 GeV upgrade), the electron accelerator needed for the EIC machine could be constructed for a modest fraction of the cost of a new facility. The combination of the energy-recovered electron linac and a (new) light-ion storage ring that is optimized for the collider application could provide a luminosity that is more than a factor of ten higher than other designs that have been considered. It would also be quite straightforward to combine a 20-30 GeV, extremely high luminosity (~10^{38}), ELFE-like external beam facility with the collider by employing the interlaced beam technique that now provides CEBAF users with three nearly independent beams. One could build the linac, and use one bunch stream to feed the collider (and recover its energy after collision by appropriate phasing of the returned beam through the linacs) and use a second (and third) bunch stream to provide external beams by recirculating without the added phase shift (therefore further accelerating the beams rather than energy recovering from them).

With either (or both) of these upgrades, Jefferson Lab would remain in the forefront of nuclear physics research for many years to come with only a modest investment of funds for capital improvements.

B. Next Generation Light Source

Stimulated by the success of the Jefferson Lab IR Demo FEL in recovering the spent FEL electron beam energy, several groups are now considering applying the same concept in accelerators of the same scale as CEBAF, but with much higher average current. Applications to high luminosity EICs for high-energy nuclear physics research, and to radiation sources for materials science studies are anticipated. Sources with a spectral brilliance in the X-ray region three orders of magnitude beyond current generation synchrotron light sources could be built at Jefferson Lab using the same tunnel as the present CEBAF accelerator. Completing a recirculating linac light source at Jefferson Lab by 2009-2010 is possible if the electron beam source development work for the 100 kW FEL, a source with specifications similar to those needed for such a light source, proceeds smoothly.

Jefferson Lab
Programmatic Strategic Goals

Program	Near–Term FY2003 - FY2007	Mid–Term FY2008 - FY2012	Long–Term FY2013 - FY2018
Nuclear Physics	Execute a world-class physics program that makes substantial progress toward addressing key issues in nuclear physics. – increase physics productivity to ~50% above FY2001 – strengthen scientific leadership - hire key staff – complete 15-20 experiments per year, addressing a significant portion of the approved program – continuously improve the overall program quality, through PAC reviews of new proposals, and mini workshops looking at the overall program – foster an awareness of and appreciation for the quality of this science in the nuclear physics community, the scientific community at large, and the public	Launch the 12 GeV physics program using new equipment and the upgraded accelerator. Decide on the broad target of scientific opportunity for the next facility (24 GeV external beam facility or electron light ion collider), by ~FY2010, then develop and refine the case for it.	Move (in a manner analogous to the 12 GeV upgrade), toward the realization of the next generation facility. – Carry out necessary R&D – Develop physics program and define accelerator and equipment needs – Foster international collaboration
	Construct new equipment as needed to support this world-class program, including: – evolutionary upgrades to keep the existing equipment at the state-of-the-art – selected major new instruments needed to address specific, high-priority issues and/or expand our capabilities to match scientific opportunities: G^0, Compton Detector, Wide Angle Calorimeters, etc.	Foster international support for the next facility.	
	Involve the international community (and High Energy Physics) to the maximum extent possible, as a basis of support for the 12 GeV facility and a bridge to the future.		
	Strengthen core competencies in nuclear physics in the design, execution, analysis and interpretation of precision experiments involving studies of nucleons and nuclei by both electron scattering and photon-induced reactions, including: – state of the art simulations; – the design, construction, and operation of super-conducting spectrometers, advanced detectors, and polarized and cryogenic targets; and – the use of very high-rate data acquisition and analysis systems.		
	Develop high performance computing and LQCD to a level that permits detailed comparison with experimental results. – Expand the R&D program in High Performance Computing including university involvement – Install and operate a highly efficient, cost optimized, multi-tera-flop/s scale computing facility – Considerably expand LQCD calculations for lab-relevant physics	Perform critical comparison of nuclear theory and experiment through LQCD calculations.	Extend LQCD calculations to multi-hadron systems.

Program	**Near–Term** **FY2003 - FY2007**	**Mid–Term** **FY2008 - FY2012**	**Long–Term** **FY2013 - FY2018**
Grand Instruments for Science – Accelerators and Lasers	$170–250M construction project to reach 12 GeV and build needed new instrumentation (FY2003–FY2010). Strengthen accelerator and SRF core competencies of the laboratory via two centers of excellence: – the CASA – the ISRFST Strengthen Jefferson Lab electron injector competency. Conduct necessary cryomodule development by FY2007 to reach 12 GeV at lowest cost. Explore 24 GeV CEBAF Upgrade and Electron Ion Collider (EIC) scenarios for nuclear physics. CEBAF-ER (energy recovery) experiment planned. Explore a 100 mA gun for the FEL ring towards a prototype electron cooler for RHIC in collaboration with BNL. Study various options in energy-recovered linacs. Explore collaborations with FNAL and DESY on TESLA and ANL, etc. on RIA. Construct, commission and operate FEL Upgrade (10 kW IR and 1 kW UV). Install and integrate HELIOS with the FEL.	Commission and operate CEBAF at 12 GeV. Develop accelerator simulations as a mature adjunct to the CEBAF and light source experimental program. Benchmark, operate, and develop upgrades for 100 kW FEL prototype. Thoroughly simulate accelerator designs for advanced facilities such as EIC and ERLs. Prepare for further upgrades to 24 GeV/EIC. Design the next generation light source on site.	Operate nuclear physics, light source, and other programs. Possible upgrade to 24 GeV <u>or</u> other options such as the EIC. Partner with DOE, DOD, and industry on off-site light sources based on core JLab technology.
Photon Science and Applications	Extend FEL Facility capabilities with rapid scanning, pulse stacking, Compton and Terahertz sources. Build a short pulse terawatt peak power Ti-sapphire laser to complement FEL. Commission and operate HELIOS X-ray Synchrotron in FEL Facility; synchronize the FEL with HELIOS. Develop simulation as a useful complement to FEL-relevant material science experiments. Develop user communities and baseline FEL Facility operational funds. Take advantage of university/lab/industry synergy in the Applied Research Center. Launch 100 kW FEL demonstration project (FY2003-2005).	Operate state-of-art light source complex (THz to X-ray) for user community with synchronized multiwavelength pulses. Play a major role in next generation light source based on 100 mA energy recovered linac.	Operate light source complex for users incorporating upgrades based on core JLab technology.

Program	**Near–Term** **FY2003 - FY2007**	**Mid–Term** **FY2008 - FY2012**	**Long–Term** **FY2013 - FY2018**
Development of Unique Scientific/ Technical Tools	Advanced Scientific Computing: – application of high performance computing to accelerator, laser and medical simulation. Investigate medical applications of advanced detector technology.	Comparison of theory, experiment and simulation of particle beams and collisions. Develop a portfolio of JLab core technologies for applications in biomedicine and security (particle and light beams, imaging, magnetic sensors, SRF, etc.)	

VI. OPERATIONS AND INFRASTRUCTURE STRATEGIC PLAN

1. SCIENTIFIC AND TECHNICAL PROGRAMS

A. Physics Program

Our understanding of the fundamental structure of matter has undergone a profound transformation in recent years. It is now known that quarks and gluons – not protons and neutrons – are the basic components of nuclei, and that they, together with electrons and photons, are the fundamental constituents of matter. Along with the discovery of quarks and gluons has come a fundamental understanding of their interactions – the "strong interactions" – so that now nuclear and subnuclear physics have, for the first time, a basis as solid as the theory on which atomic and molecular physics are built. There is a striking analogy between the latter well-established sciences and the physics of quarks and gluons: the proton and neutron are now believed to be "quark atoms" (bound states of quarks held together by gluons) just as ordinary atoms consist of electrons bound by photons to the atomic nucleus. Moreover, nuclei themselves may be considered analogous to molecules, both being relatively weakly bound compounds of their respective "atoms".

The fundamental theory of strong interactions, called QCD, guides experimentation at Jefferson Lab's CEBAF. Although it is assumed that QCD is exact, it has only been tested in the very high energy regime, where the interaction becomes weak and perturbative calculations are feasible. The scientific goal of CEBAF is to investigate the transition region between this "asymptotically free" high-energy regime and the strongly interacting regime, where our understanding of the underlying physics is very rudimentary, and where the matter we see around us is formed. CEBAF's high energy, continuous-wave electron beam is an ideal probe for the study of this transition region, since the electromagnetic interaction is well understood, the electron has no internal structure, and its electrons (with available energies up to 6 GeV) can probe distance scales ranging from the size of a large nucleus down to about $1/10^{th}$ the size of the proton.

The small cross sections of the electromagnetic interaction and the systematic nature of the required investigations mean that experiments often require months of beam time to produce meaningful results. The productivity of CEBAF's scientific program is enhanced significantly by the accelerator's ability to provide three simultaneous continuous beams of independent current and independent but correlated energy, permitting as many as three experiments to run in parallel. The availability of polarized electron beams extends the capabilities of the facility to include both spin-transfer reactions and parity violation experiments, which probe, respectively, the spin and the weak neutral current structures of the system under study.

The three experimental Halls at Jefferson Lab have been equipped with instrumentation that was carefully selected to emphasize complementary aspects of the scientific program, further enhancing the versatility of the facility. Hall A has a pair of high-resolution magnetic spectrometers optimized for precision electron-scattering coincidence experiments. Hall B has a large acceptance (nearly 4π) detector and ancillary equipment (including a photon tagger) that supports broad-ranging studies of both electron- and monochromatic photon-induced reactions with loosely correlated particles in the final state and experiments involving low luminosity.
Hall C has a pair of moderate resolution spectrometers, with one capable of high-momentum particle detection and the second optimized for the detection of short-lived reaction products. Hall C also has additional space and infrastructure to support major new setups for specific measurements not well suited to the basic instrumentation in any of the three Halls.

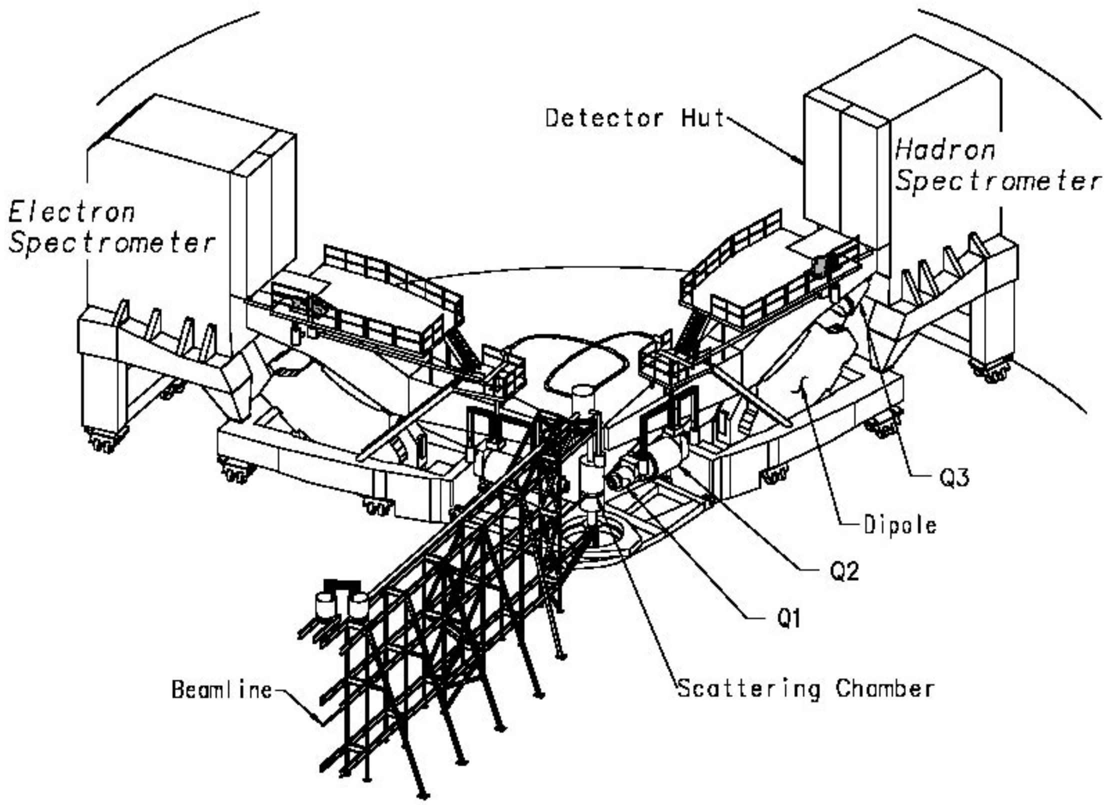


Figure VI-1: The Hall A High Resolution Spectrometers (HRS)

Hall A

Initial commissioning activities in Hall A began in the spring of 1996, and the experimental program began in May 1997. The Hall is equipped with two optically identical, high-resolution ($\delta p/p=10^{-4}$) magnetic spectrometers (HRS Figure VI-1); each has a relatively large solid angle and a maximum momentum of 4 GeV/c. The detector packages have been optimized differently: one for detecting electrons and one for detecting hadrons. The detector package in the hadron spectrometer includes a focal plane polarimeter. The spectrometers are performing as designed. As of June 2002, twenty-three experiments have been completed in Hall A, roughly half the desired data have been obtained (intentionally) on two more, and one tenth of the data on another. The Hall A spectrometers are being utilized for detailed investigations of the structure of nuclei, mainly using the $(e,e'p)$ and $(\vec{e},e'\vec{p})$ reactions. The measurements are extending the range of momentum transfers and internal nucleon momenta investigated well beyond the previously known region. These measurements are revealing the limitations of the conventional picture of nuclear structure, based on nucleons interacting via meson exchange, which is adequate for describing the low-momentum transfer regime. Experiments of this type in heavy nuclei are expanding our understanding of nuclear structure, and providing information on how the nucleon's properties change when it is embedded in the nuclear medium. In few-body systems, where exact calculations can be performed in the conventional, nucleon-based description of nuclei, experiments have shown that the nucleon–meson exchange picture works to distance scales of order 0.5 fm (half the n-p spacing in the deuteron), but it becomes increasingly difficult to use this picture to explain photodisintegration data at higher energies that are probing shorter distance scales. At higher energies simpler models based on quarks or constituent counting rules provide a more economical qualitative description of the experimental data.

Studies of the electromagnetic and weak neutral current structure of the nucleon are also important components of the Hall A program. The HRS spectrometers are measuring the charge and magnetic form factors of nucleons with greatly improved accuracy. The first of these experiments, a measurement of the ratio of the electric and magnetic form factors of the proton to high Q^2, already has provided one of the most interesting results from the CEBAF program. The data have demonstrated unequivocally that the radial distribution of charge and magnetization in the proton differ significantly, and are providing a stringent test for quark-based models that should describe the proton's internal structure.

Other planned experiments in the area of nucleon structure include virtual and real Compton scattering, which probe the low-energy structure of the proton and its excited states. A detailed study of spin observables in the $N \rightarrow \Delta$ transition also has been performed. The strange-quark contributions to the charge and magnetization distributions of the nucleons are being investigated via very precise parity-violating electron scattering experiments. These experiments will provide stringent tests for microscopic models of the quark-antiquark "sea" of the proton. The first of them, E91-010, demonstrated the ability of the accelerator and experimental equipment to carry out these demanding experiments. The results of that experiment imply that either the $s\bar{s}$ sea is unexpectedly weak or that the s and $\bar{s}$ electric and magnetic distributions are unexpectedly similar very similar, so they tend to cancel.

Hall B

The final Hall to begin physics operations, is equipped with a large acceptance (nearly 4π) detector, the CEBAF Large Acceptance Spectrometer (CLAS), which is shown in Figure VI-2. It was designed to carry out experiments that require the simultaneous detection of several loosely correlated particles in the hadronic final state, and to be able to perform measurements at limited luminosity.

The magnetic field in the CLAS has a toroidal configuration generated by six iron-free superconducting coils. Its particle detectors consist of drift chambers to determine the trajectories of charged particles, Cherenkov counters for the identification of electrons, scintillation counters for the trigger and for time-of-flight measurements, and electromagnetic calorimeters to identify electrons and to detect photons and neutrons. The continuous nature of the CEBAF beam is critical to the functioning of such a multi-particle coincidence detector. Hall B also includes a bremsstrahlung photon tagging facility so that the CLAS can investigate real as well as virtual photon processes.

A major research program for the CLAS is the investigation of the quark-gluon structure of the nucleon, especially the detailed study of its spectrum of excited states. As in atomic physics, the spectrum of this system contains vital information on the nature of its constituents and the forces between them. It is not understood why the naïve constituent quark model is so successful in explaining the particle spectrum discovered so far. CLAS will either support this model by discovering the complete pattern of states it predicts or, more likely, it will reveal its shortcomings.

One reason it is doubtful that the simple quark model will continue to be successful is that it ignores the gluons that QCD guarantees are plentiful in the proton. While there is no evidence yet for states involving gluon excitation, models indicate that most of the predicted "gluonic" states will decay in complicated many-particle modes that would not have been observed with the previous generation of detectors. CLAS is being used for an initial search for such states, but a definitive search will require the 12 GeV electron beams of the energy upgrade project and a new, optimized detector (planned for the new Hall D to be constructed as part of the upgrade).

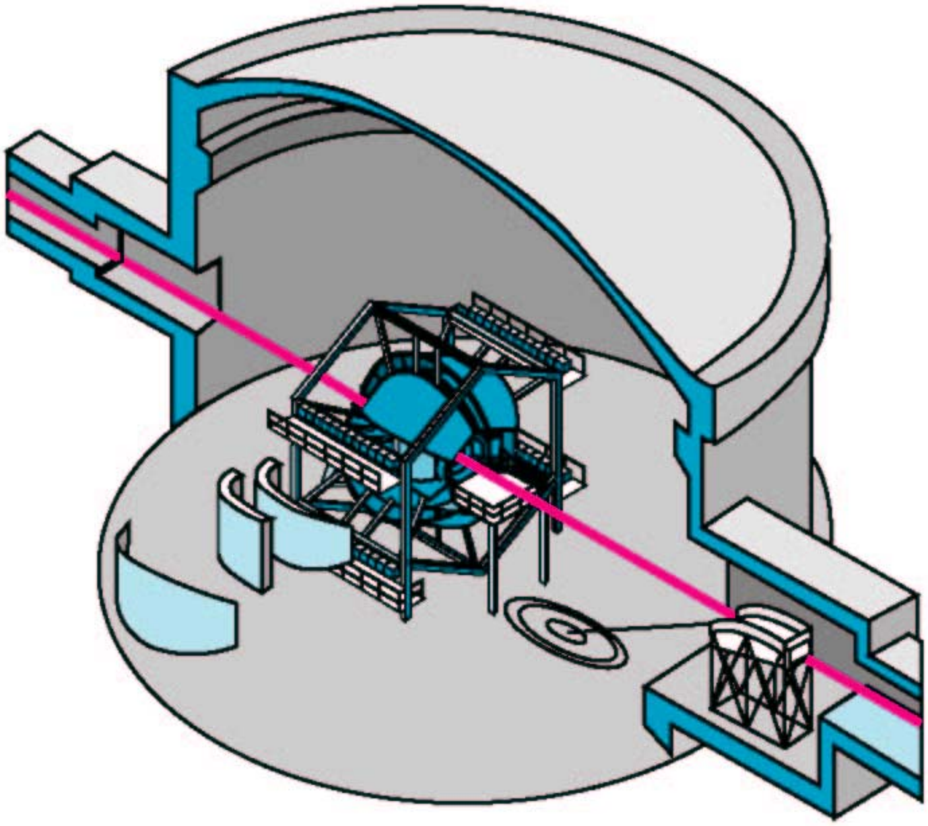


Figure VI-2: Hall B instrumentation

The CLAS spectrometer is also being used in a variety of other investigations requiring data on multi-particle final states, including short- range correlations between nucleons in nuclei, the importance of three-body forces in nuclei, and the modification of the nucleon's properties in the nuclear medium.

Commissioning of the CLAS was completed in November 1997, and physics research began in December of that year. Since then, CLAS has taken the complete data for twenty-seven experiments and partial data on a total of twenty-eight more experiments. CLAS is now operating at its design luminosity, and typical figures-of-merit used to characterize the device, such as energy resolution, position reconstruction accuracy, and time-of-flight resolution, all are within their design values. Data acquisition speed has exceeded the design values by a factor of two.

The first experiments to use CLAS were in the e1 run group (data involving electron scattering from an unpolarized proton target); it began taking data in December 1997. Most running of CLAS involves simultaneous data taking by a number of experiments, all using the same operating conditions for the beam, the target, and the spectrometer. The e1 group includes fourteen experiments involving electron scattering from the proton. A measure of the power of this new device is that in one week of running, CLAS provided a data set on single pion electro-production roughly equal to the worldwide sum of all previous data in this energy and momentum transfer regime, and a data set on double pion electro-production that is an order of magnitude larger than previously available data.

Hall B operation generally has involved interleaved running of different "groups" that have been created for experiments with common running conditions. These include unpolarized and polarized proton and deuteron targets, $A \geq 3$ nuclear targets, and incident beams of photons and polarized or unpolarized electrons. In addition, three unique experiments involving special conditions (or even different apparatus) have been run. As of now we have obtained complete data for seven of the run groups, more than half the ultimate data set for four more run groups, and complete data for two unique experiments. The completed data sets correspond to 45 experiments.

Hall C

Hall C's initial complement of equipment, shown in Figure VI-3, includes two general-purpose magnetic spectrometers. The High Momentum Spectrometer has a large solid angle, a moderate resolution (10^{-3}), and a maximum momentum of 7 GeV/*c*. The Short Orbit Spectrometer has a large momentum acceptance and a very short (7.4 meter) optical path to facilitate the detection of particles having short lifetimes, such as π's and K's. All equipment is operating at design specifications.

Since the start of the physics program in November 1997 through June 2002, a total of seventeen experiments have been completed in Hall C covering a broad spectrum of topics in nuclear physics, and about half the desired data has (intentionally) been obtained on one additional experiment. Experiments using the standard equipment in the Hall have investigated a broad variety of phenomena including the pion form factor, deuteron photodisintegration at high energies, color transparency, kaon production, excitation of the delta resonance in the proton, duality, and deep inelastic scattering in nuclei for $x > 1$.

Hall C was planned to support the installation of additional specialized detectors designed to investigate specific problems. Examples to date include: the t_{20} experiment (E94-018), which separated the elastic form factors of the deuteron to high momentum transfer (a key element of the result discussed above under Hall A); the Hyper Nuclear Spectrometer System (HNSS) experiment (E89-009), which demonstrated the feasibility of performing hypernuclear physics experiments at Jefferson Lab. Two major installation experiments have made a precision determination of G_E^n, the electric form factor of the neutron, to high Q^2: E93-038, a measurement using a high current polarized electron beam and a neutron polarimeter, and E93-026, a second, complementary measurement using a polarized target and low-current polarized beam.

A hypernucleus is a nucleus in which one of the nucleons has been replaced by its strange counterpart, the Λ hyperon. Experiments in which hypernuclei are formed using electroproduction are complementary to those involving the more traditional pion-production approach, as they emphasize unnatural parity and high-L states, where pion production emphasizes natural parity and low-L states. With the HNSS experiment successfully completed, the collaboration has been hard at work on the next phase of the program, which includes the construction of a major new spectrometer facility (funded primarily by our Japanese collaborators). The PAC has approved the facility and its first experiment.

Additional "major installation" experiments planned in Hall C include:

- Precision measurements of parity violation in the scattering of polarized electrons from protons to investigate their weak neutral current structure and possible contributions from strange quarks (E91-017), to be carried out using a major new specialized apparatus now nearing completion – the G^0 spectrometer.

- A precision test of the theory of electro-weak interactions that measures the Q_{weak}, the weak charge of the proton, at low Q^2, where it hasn't yet been tested.

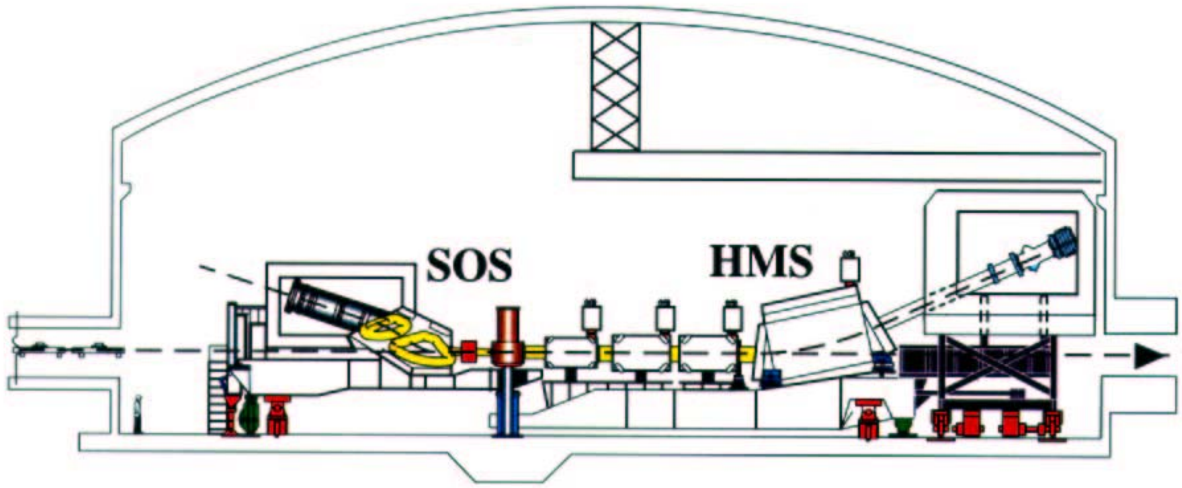


Figure VI-3: Hall C and its initial complement of equipment

- The G^0 experiment will measure the contribution of the s and $\bar{s}$ quarks to the magnetization and charge distributions of the proton and neutron down to a few percent of their "natural" values of unity.

Theory

Jefferson Lab maintains a strong nuclear theory group in partnership with Hampton University, Old Dominion University, and the College of William and Mary. The group includes expertise spanning a broad range from the nuclear many-body problem to strong QCD, as appropriate for a laboratory working at the traditional interface between nuclear and particle physics. In addition to supporting the CEBAF experimental program directly, Jefferson Lab theorists collaborate closely with other theorists around the world on CEBAF-related problems.

Last year was a typically productive one for the Theory Group. The group published 26 new papers in refereed journals, gave 30 talks at international conferences and workshops that will be published in conference proceedings, and gave another 15 invited talks at major conferences which publish no proceedings. The Theory Group's papers continue to be so frequently cited that several have appeared on "top ten" citations lists. The group continues its sponsorship of workshops on specialized topics related to the CEBAF program, and a seminar program aiming to bring important new developments in theory to the attention of the Laboratory and user community. To supplement this program, the Theory Group continues to run its highly successful Mini-Lecture Series of short courses for experimentalists on key new developments in nuclear theory.

Finally, the theory group is intimately involved in the new, LQCD effort outlined in Section IV.1.F above.

Accelerator and Experimental Area Operations and Hours Available for Research

Jefferson Lab has a performance-based contract with DOE that emphasizes the shared goal of maximizing the research productivity of the Laboratory. Key metrics for the operation of the research program include the simultaneous availability of the accelerator and the experimental equipment, the availability of the accelerator alone, the availability of the experimental equipment alone, and the experiment multiplicity (the number of experiments that are receiving beam simultaneously, on average).
As we improve the accelerator and the experimental equipment, the availability should increase significantly; the goals for the accelerator

availability outlined in Appendix B of our contract increased from 50% (in FY96) to 80% (in FY99 and beyond). The performance goals are adjusted each year to properly reflect what is possible for the level of funding provided, and also for unusual activities such as the initial operation at significantly higher beam energy or installation of a major device such as the polarized source. Similar goals have been set for each experimental Hall, with the starting year being the first year of physics operation, Hall-by-Hall. If we can execute this plan well, the overall operational efficiency (the product of accelerator and Hall availabilities) should reach about 65%. In addition, the average experiment multiplicity should exceed two in full operation, limited by the manpower available for tearing down and re-installing specialized equipment between experiments.

We have experienced serious difficulties in achieving the desired availability due to the increasing demands placed on the accelerator by the evolving research program in the context of tight funding. Carrying out the physics experiments with the highest scientific priority requires excellent beam quality, highly polarized beams, and a large dynamic range of currents in multiple beam delivery. It also requires the use of high-power cryotargets, polarized targets, and a variety of complex new experiment installations. These ongoing, science driven modifications make it more difficult to improve the overall efficiency, i.e., the product of machine availability, equipment availability, and hall multiplicity. Sub inflation budgets over several years exacerbated this situation, and under this stress, the overall operational efficiency, which had risen from 56% in FY98 to 66% in FY2000, dropped to 57% in FY2001, and just barely recovered FY 2000 values for the first 3 quarters of FY2002. The effect of this efficiency is compounded by the fact that we have had to cut back on accelerator operations beginning in FY1999 from 32 to 28 weeks/year for physics in FY2002. Despite the fact that we have launched an aggressive program aimed at addressing operations efficiency, we have only been able to achieve a level slightly below FY2000.

In FY2002, the Nuclear Physics funding received was $1.7M less than inflation above FY2001. Chapter IV details the resources needed to optimize JLab's scientific program. The FY2004 increment in operating funds indicated on Table IV-1 will permit us to increase the weeks of accelerator operating from 28 weeks in FY2002 to 35 weeks in FY2004, and a resulting increase in delivered physics research operations (weeks of research operations when both beam and experimental equipment are operating simultaneously, a key metric which also includes the productivity resulting from multiple hall operation) from 37 weeks in FY2002 to 53.6 weeks in FY2004 and to raise the accelerator operations efficiency and experiment multiplicity by an amount that will increase the scientific productivity by 43%.

New Experimental Equipment Initiatives

There was a large investment in the initial equipment for the three experimental Halls for CEBAF at Jefferson Lab, as outlined above. This base equipment is CEBAF's "workhorse" equipment, but it will always be necessary to construct both new and ancillary devices to carry out "standard" high-priority experiments that have already been approved and new instrumentation to respond to exciting new scientific initiatives. Over time, it will be necessary to modify the existing equipment to improve its reliability and to keep its performance at state-of-the-art. Eventually, we will have to replace major end station apparatus to keep the facility's capabilities at the cutting edge of nuclear physics research. We request equipment funds each year to respond to these needs. The funds are divided between Jefferson Lab and collaborating user groups in a manner similar to that used for the construction of the base equipment in the Halls. Funding for such initiatives has already served many useful purposes. In Hall C, it has supported the development of the t_{20} deuteron channel, the HNSS, and the neutron polarimeter for one of the two G_E^n measurements. A variety of specialized targets, including unpolarized, high-power cryotargets for hydrogen, deuterium and helium, and polarized targets for hydrogen, deuterium and ^{3}He have been developed for all three Halls.

Basic beamline instrumentation has been enhanced with the addition of a number of devices such as the beam polarimeters in Halls A and B.

Plans for the near-term future in Hall A include: septum magnets that will allow us to use the spectrometer pair at scattering angles as far forward as 6^o; and upgrades of the HRS detectors, and particle hodoscopes. Hall B projects are: a pair spectrometer that will be used both for photon beam monitoring and for the Primakoff experiment PRIMEX (which will perform an accurate measurement of the $\pi^\circ \rightarrow \gamma\gamma$ coupling constant); and an electronics system that will permit parasitic checking of the CLAS drift chamber performance during data-taking. Two multi-year projects are underway in Hall C: the G^0 spectrometer (which is being installed now and will be commissioned later this year) and the second-generation hypernuclear system (both discussed briefly above). A third project, the construction of the apparatus for the Q_{weak} experiment, is a major new initiative now under development.

Equipment funding will continue to be used to improve beam-line instrumentation, to build upgraded polarized and cryotargets for all three Halls; and to develop general-purpose infrastructure for polarized and cryogenic target development and support at the laboratory. We will also begin a key effort to carry out the R&D necessary to refine design choices and optimize performance for the new detectors needed for the 12 GeV upgrade equipment. Continued funding of this type is critical to the long-term success of the research program.

Data Acquisition

The data acquisition systems in all three Halls are operating reliably at data rates and event rates that meet the requirements of experiments approved for the next few years. The installed systems will continue to be improved in terms of stability and throughput to increase the yield of physics data from the Halls, to meet the requests of experimenters for new features, and to keep pace with the ever-increasing demands of the experiments.

There are two main challenges for data acquisition at Jefferson Lab. Both stem from a common source: the rapid evolution of computing software and hardware. The first challenge is that the hardware currently in use in all three Halls is rapidly becoming, or is already, obsolete. During the next five years we must actively pursue new hardware technologies to maintain and upgrade our data acquisition systems. The second challenge is that computer hardware and software are evolving so rapidly that a considerable effort is expended ensuring that software systems are portable from old systems to new. This includes the problem of ensuring that newer and older systems can communicate with each other. We intend to meet this challenge on several levels. Adopting commercial communications protocols guarantees continuity across platforms, as does increasing the use of platform independent technologies such as JAVA. Our support of embedded operating systems is being diversified from VxWorks to include Linux. We are also increasing our use of model-centered, rather than code-centered, programming techniques to increase the portability and maintainability of our software.

Data Reconstruction and Analysis

The computing facilities for data reconstruction and analysis have been built up since 1995 in concert with the ramp up of the experimental program. Recent data rates to tape regularly exceed 20 MB/s, with accumulations of up to 1 TB of data per day. Tape storage was augmented at the end of FY2001 with the addition of a second robotic silo giving a capacity of 12,000 tapes. This will provide sufficient storage capacity for the steady-state experimental program over the next few years.

The storage system is currently equipped with eight RedWood (50 GB tape capacity), ten 9840 (20 GB tape capacity), and fifteen 9940 (60 GB tape capacity) drives. The 9840 drives were introduced to improve overall tape accessibility since, although the tapes have a lower capacity, they have a much faster load and access time than the RedWoods and are very suitable for storing frequently accessed data sets. Due to the mechanical unreliability, short tape-head lifetimes, and high maintenance costs of the RedWood drives, we are proceeding with a program of replacing them with newer technology 9940 drives that are capable of equivalent data rates with 60 GB tape capacity. Fifteen of these drives are in place, and the migration of data from RedWood to 9940 media is expected to be complete around the end of CY2002, at which time the RedWood drives will be removed. The combination of the 9940 and 9840 tapes and drives provide complementary abilities for a wide range of usage, and with the expected evolutions of these drive technologies we have an upgrade path for at least the next five years that will retain backwards compatibility for the media.

The mass storage silos are managed by a locally written software package – Jasmine – that was put into production in May 2001. This new system provides not only control of the silos and tape drives but integrates the disk pool management to provide a complete mass storage management system. This software was designed as a distributed system that provides high performance and that will scale with the expansion of the tape and disk subsystems to provide adequate performance for all needs for the foreseeable future, including anticipated data acquisition rates of up to 100 MB/s. The system has no single point of failure, and is able to provide storage access even while individual components are upgraded or replaced.

The mass storage architecture now includes over 25 TB of disk pools, which is expected to expand by some 10 TB per year over the coming years. These disk pools are constructed from aggregated storage servers based on Linux systems and utilize either IDE or SCSI disk depending on expected usage modes. These storage systems are presented to the user in an integrated namespace. Uses vary from staging space for data moving between tape storage and the processing farm, to storage for frequently accessed data, to working space for analysis projects.

The mass storage system currently stores some 550 TB of data, which is increasing at a rate of about 150 TB per year. The tape subsystem handles a total well in excess of 2 TB/day (and up to 6 TB/day during data migration).

The reconstruction and analysis system consists of a farm of 350 compute nodes, providing some 11000 SPECint95 of processing power. This farm is built from dual Intel CPUs running the Linux operating system. In addition to the batch systems, interactive analysis capability is provided centrally with two 4-processor Solaris systems and two 4-processor Linux systems. A moderate expansion of the batch and interactive computing systems is foreseen over the coming years, including a program of replacing older systems.

The network supporting data reduction and analysis is entirely high-throughput Gigabit Ethernet, except to individual farm nodes that have 100 Mbit/s links to a switch where 24 nodes share a Gigabit uplink to the mass storage systems. The general-purpose backbone network infrastructure is built around Gigabit Ethernet, with 100 Mbit/s connections to physicists' desktop systems to permit fully distributed and efficient analysis and data access. As data analysis needs grow, more and more analysis will be done at collaborating institutions. In addition, more and more simulated data created at off-site locations must be moved to Jefferson Lab and subsequently analyzed and shared with collaborators.

To facilitate these activities, we are participants in the Particle Physics Data Grid (PPDG) collaboration, with a goal of providing computing and data "grid" services to enable transparent, efficient, and secure access to data and compute resources. As part of this effort we are currently deploying pilot systems to FSU to enable remote access to the Jefferson Lab storage system and the ability to run jobs at either site providing cross-site load balancing. This three-year project will provide the tool kit ("middleware") on which to build fully grid-enabled applications that should allow physicists to access and manipulate data in an intuitive way no matter where the data or compute resources are physically located. Although the PPDG involves US DOE Laboratories and Universities, it is part of a huge international focus across many scientific disciplines and industrial partners to provide a ubiquitous computing grid of infrastructure and services.

The Experimental Program

CEBAF's research program was planned with the active participation of our user group, which now has over 2,100 members. Collaborations were formed within this group to build the spectrometers, detectors, and data acquisition systems and to propose experiments. These users contributed well over 400 man-years of effort to the construction of the initial complement of experimental equipment and are playing a major role in the various upgrade and new equipment projects underway.

A total of 1011 scientists from 167 institutions in 29 countries are collaborators on one or more of the approved experiments; their home institutions are listed in the tables attached to the end of this section, and summarized in Table VI-1 (immediately below). Table VI-2 presents a breakdown of the approved and conditionally approved experiments by physics topic and by Hall. Table VI-3 summarizes the status of the experimental program as of June 2002. A total of 77 experiments have been completed, as well as major fractions of 21 more (corresponding to an equivalent of about 11 additional completed experiments). Thus we have completed about two thirds of the presently approved program. Completing the remainder of the presently-approved program would require about four years of running the accelerator for 30 weeks/year with an overall operational efficiency (product of Hall and accelerator availability) of ~60%.

The process of deciding which experiments should be run and the order for running them is critical to the productivity of the research program of CEBAF at Jefferson Lab. A key element in this process is the traditional mechanism of an external PAC, consisting of distinguished physicists who are experts in the field of nuclear physics and chosen to provide broad perspective. Prior to presentation to the committee, the Physics Division's Technical Advisory Committee (which includes representatives from the Accelerator Division) reviews each proposed experiment for feasibility and impact on the Laboratory's resources. The PAC reviews proposed experiments on the basis of their scientific merit, technical feasibility, and manpower requirements, and makes scientific ratings and recommendations to the Laboratory's Director, who makes the final decision.

To develop the running schedule, the PAC ratings are considered together with the demonstrated technical capabilities of the accelerator and experimental equipment and a detailed understanding of the long-term goals of the research program. This schedule is released at the end of the second and fourth quarter of each fiscal year, three months before the beginning of a siX-month running cycle. The schedule for major new experiments requiring long lead times and large-scale equipment installation is determined a year in advance.

An element of the experiment approval process that is important to the long-term evolution of the program is "jeopardy" – any experiment that has not run within three years of approval, for whatever reason, must return to the PAC for a new review (which will include a new rating for its scientific priority) or lose its approved status. This system provides a means of continually improving the overall quality of the science as the field moves forward, and avoids the situation where an old, modest-priority experiment waits in the queue for an unconscionably long time. Because many experiments were approved well before accelerator operations began, "jeopardy" is being implemented separately in the three Halls; the three-year period is measured in each Hall from the start of physics operations in the Hall or the date of approval of the experiment, whichever is later. The jeopardy review process began with the January 1999 meeting of PAC15; the first round was completed for all three Halls during PAC21 in January 2002.

Jefferson Lab incorporates the expertise and vision of PAC members in its planning process through workshops and reviews. A broad review of the overall science program began with a workshop/review of our few-body physics program held immediately following PAC14. Reviews of the programs on “nucleon and meson form factors and sum rules,” “properties of nuclei,” and “strange quarks” were held following PACs 15, 16, and 17, respectively. The review of the N* and meson properties program will be held soon.

PAC15 also initiated the process for planning the scientific program and equipment complement for the 12 GeV upgrade; this review is broadly based on the PAC involvement that was so successful in defining the initial equipment complement for CEBAF. Its advice is augmented by high-level input from our Science and Technology Peer Review Committee. The PAC review included a major session at PAC19 that considered all of the science proposals used to motivate the upgrade in the “White Paper” presented to the NSAC Long Range Plan. We will continue PAC involvement in planning for the upgrade with a second session at PAC23 early in 2003.

The experimental program that has resulted from this deliberate and thoughtful process is broad in scope and covers many of the most interesting topics in nuclear science today. The approved experiments are listed by title in Table VI-4. Running this program successfully is the Laboratory’s highest priority and the central focus of our near-term planning.

Table VI-1
Users On Experiments, June 2002

User Home Institution	Number of Experimenters	Number of Organizations
Universities (U.S.)	551	84
International	343	72
Other Federal Laboratories	49	10
Jefferson Lab	68	1
TOTAL	1,011	167

Table VI-2
Approved Experiments by Physics Topic, June 2002
(including completed and partially completed experiments)

Topic	Number of Experiments			
	Hall A	Hall B	Hall C	Total
Nucleon and Meson Form Factors and Sum Rules	8	4	9	21
Few Body Nuclear Properties	16	5	5	26
Properties of Nuclei	7	9	8	24
N* and Meson Properties	6	27	7	40
Strange Quarks	4	11	2	17
TOTAL	41	56	31	128

Table VI-3
Experimental Program Status, June 2002

Hall	Approved Experiments				Cond. Approved Expts
	# Expts Completed (full/partial)	Total Days Run	# Expts in Queue	Days to Be Run	
A	25 / 1	466.0	18	306.9	2
B	35 / 19	385.1	23	153.3	2
C	17 / 1	388.5	15	283.0	2
Total	77 / 21	1239.6	56	743.2	6

Table VI-4
Jefferson Lab Approved Experiments

Key: ★ = complete
☆ = partially complete;
★/ = original experiment partially completed but considered complete by collaboration as major goals were achieved (no additional running planned);
$\bar{☆}$ = partially complete, but continuation halted by PAC during a jeopardy review)

Few Body Nuclear Properties

Exp. #	*Hall*	*Title*
★E-89-012	C	Two-Body Photodisintegration of the Deuteron at Forward Angles and Photon Energies between 1.5 and 4.0 GeV
★E-89-019	A	Measurement of Proton Polarization in the d(χ,p)n Reaction
★E-89-028	A	Polarization Transfer Measurements in the D(e,e'p)n Reaction
★E-89-044	A	Selected Studies of the ^{3}He and ^{4}He Nuclei through Electrodisintegration at High Momentum Transfer
$\bar{☆}$E-91-003	C	A Study of Longitudinal Charged Pion Electroproduction in D2, He3, and He4
★E-91-026	A	Measurement of the Electric and Magnetic Structure Functions of the Deuteron at Large Momentum Transfers
★/E93-017	B	Study of γd -> pn and γd -> pΔ^0 Reactions for Small Momentum Transfers
☆E-93-044	B	Photoreactions on ^{3}He
★E-93-049	A	Polarization Transfer in the Reaction ^{4}He(e,e'p)^{3}H in the Quasi-elastic Scattering Region
☆E-94-004	A	In-Plane Separations and High Momentum Structure in d(e,e'p)n
★E-94-018	C	Measurement of the Deuteron Tensor Polarization at Large Momentum Transfers in D(e,e'd) Scattering
★E-94-019	B	Measuring Nuclear Transparency in Double Rescattering Processes
★E-94-102	B	Electron Scattering from a High Momentum Nucleon in Deuterium
★E-94-104	A	The Fundamental gamma n->pi$^-$rho Process in ^{2}H, ^{4}He, and ^{12}C in
★E-95-001	A	Precise measurements of the Inclusive Spin-dependent Quasi-elastic Transverse Asymmetry A_T from ^{2}H(e,e') at low Q^2
★E-96-003	C	Two-Body Photodisintegration of the Deutron at High Energy
☆E-97-001	B	Electroproduction of the ppπ^- System off the Deuteron Beyond the Quasifree Region
★E-99-008	A	Large Angle Two-Body Photodisintegration of the Deuteron at High Energy
E-00-007	A	Proton Polarization Angular Distribution in Deuteron Photo-Disintegration
E-00-107	A	Proton Polarization in Deuteron Photodisintegration to E_γ > 3 GeV at θ_{cm}=90^o
E-00-118	A	Elastic Electron Scattering off ^{3}He and ^{4}He at Large Momentum Transfers
E-01-020	A	Short Distance Structure of the Deuteron and Reaction Dynamics in 2H(e,e'p)n and A Study of the Dynamics of the Exclusive Electrodisintegration of the Deuteron
E-01-107	C	Measurement of Pion Transparency in Nuclei
E-01-108	A	Detailed Study of the ^{4}He Through Response Function Separations at High Momentum Transfers
E-02-004	A	A(Q) at Low Q in ed Elastic Scattering
E-02-010	A	The Gamma + n ->pi^- p Process from 2H and 12C and the gamma + p -> pi^+ n Reaction

N and Meson Properties*

Exp. #	Hall	Title
☆E-89-037	B	Electroproduction of the P_{33}(1232) Resonance
☆E-89-038	B	Measurements of p(e,e'π^+)n, p(e,e'p)π^0, and n(e,e'π^-)p in the Seco
☆E-89-039	B	Amplitudes for the S_{11}(1535) and P_{11}(1710) Resonances from an ep=>e'pn experiment
☆E-89-042	B	Measurement of the Electron Asymmetry in p(e,e'p)π^0 and p(e,e'π^+) in the Mass Region of the P_{33}</SU< td>
☆E-91-002	B	The study of Excited Baryons at High Momentum Transfer with the CLAS Spectrometer
★/E-91-008	B	Photoproduction of η and η' Mesons
★E-91-011	A	Investigation of the N->Δ Transition via Polarization Observables in Hall A (previously titled- High-Precision Separation of Polarized Structure Function
☆E-91-024	B	Search for "Missing" Resonances in the Electroproduction of omega Mesons
☆E-93-006	B	Two Pion Decay of Electroproduced Baryon Resonances
☆E-93-012	B	Electroproduction of Light Quark Mesons
★E-93-031	B	Photoproduction of Vector Mesons at High t
★/E-93-033	B	A Search for Missing Baryons Formed in γp -> p$\pi^+\pi^-$ Using the CLAS at CEBAF
★E-93-036	B	Measurement of Single Pion Electroproduction from the Proton with Polarized Beam and Polarized Target Using CLAS
★E-93-050	A	Nucleon Structure Study By Virtual Compton Scattering
☆E-94-005	B	Determination of the NΔ Axial Vector Tansition Form Factor $G_A^{N\Delta}$ from the ep -> e'
★/E-94-008	B	Photoproduction of η and η' Mesons from Deuterium
★E-94-012	A	Measurement of Photoproton Polarization in the H(γ,p)π^0 Reaction
★E-94-014	C	The Δ(1232) Form Factor at High Momentum Transfer
★/E-94-015	B	Study of the Axial Anomaly using the $\gamma\pi^+$ to $\pi^+\pi^0$ Reaction Near Thr
★E-94-016	B	A Measurement of Rare Radiative Decays of the ϕ Meson
★/E-94-103	B	The Photoproduction of Pions
☆E-94-109	B	Photoproduction of the Rho Meson from the Proton with Linearly Polarized Photons
★E-94-110	C	Measurement of R= Sigma L/Sigma T in the Nucleon Resonance Region
★E-99-005	B	Meson Spectroscopy in Few-Body Decays
☆E-99-013	B	Photoproduction of omega mesons off protons with linearly polarized photons
E-99-014	B	A Precision Measurement of the Neutral Pion Lifetime via the Primakoff Effect
★E-99-105	B	Deeply Virtual Electroproduction of Vector Mesons
★E-99-107	B	N* Excitations at High Q2 in the p pi, p , and n pi+ Channels
★E-99-108	B	N* Excitations at High Q^2 in the Two-Pion Channel
★E-99-114	A	Exclusive Compton Scattering on the Proton
★E-99-117	A	Precision Measurement of the Neutron Asymmetry A_1^n at Large x using CEBAF at 6 GeV
★E-99-118	C	Measurement of the Nuclear Dependence of R=sigma_L/sigma_T at Low Q2
E-00-002	C	F_2^N at Low Q^2
E-00-116	C	Update E97-010: Measurement of Hydrogen and Deuterium Inclusive Resonance Cross Sections at Intermediate Q2 for Parton-Hadron Duality Studies
E-01-002	C	Update to E97-101: Baryon Resonance Electroproduction at High Momentum Transfer
★E-01-006	C	Update to 96-002 - Precision Measurement of the Nucleon Spin Structure Functions in the Region of the Nucleon Resonances
E-01-014	A	Precision Measurement of Electroproduction of π^0 near Threshold: A Test of Chiral QCD Dynamics
★E-01-017	B	Extension to E99-005: Meson Spectroscopy in Few-Body Decays
★E-01-112	B	Photoproduction of Vector Mesons off Nuclei - Update to 94-002
E-02-012	B	Coherent Vector Meson Production off the Deuteron

Nucleon and Meson Form Factors and Sum Rules

Exp. #	*Hall*	*Title*
★E-91-023	B	Measurement of Polarized Structure Functions in Inelastic Electron Proton Scattering using the CEBAF Large Acceptance Spectrometer
★E-93-009	B	The Polarized Structure Function G_{1n} and the Q^2 Dependence of the Gerasimov-Drell-Hearn Sum Rule for the Neutron
★E-93-018	C	Longitudinal/Transverse Cross Section Separation in $p(e,e'K^+)\Lambda(\Sigma)$ for $0.5<=Q^2<=2.0\ (GeV/c)^2$,W
★E-93-021	C	The Charged Pion Form Factor
★E-93-026	C	The Charge Form Factor of the Neutron
★E-93-027	A	Electric Form Factor of the Proton by Recoil Polarization
★E-93-038	C	The Electric and Magnetic Form Factors of the Neutron From the d(e,e'n)p Reaction based on PR-89-005 [originally two proposals PR-93-038(electric) and -039(magnetic)]
★E-94-010	A	Measurement of the Neutron (^{3}He) Spin Structure Function at Low Q^2
★E-94-017	B	The Neutron Magnetic Form Factor from Precision Measurements of the Ratio of Quasielastic Electron-Neutron to Electron-Proton Scattering in Deuterium
★E-97-103	A	Search for Higher Twist Effects in the Neutron Spin Structure Function $g_2^n(x,Q^2)$
E-97-110	A	The GDH Rule and the Spin Structure of ^{3}He and the Neutron Using Nearly Real Photons
★E-99-007	A	Measurement of G_{EP}/G_{MP} to $Q^2 = 5.6\ GeV^2$ by the Recoil Polarization Method
E-00-101	C	A Precise Measurement of the Nuclear Dependence of Structure Functions in Light Nuclei
E-00-108	C	Duality in Meson Electroproduction
E-01-001	A	New Measurement of (G_E/G_M) for the Proton
E-01-004	C	Extension to E93-021: The Charged Pion Form Factor
E-01-012	A	Measurement of Neutron (^{3}He) Spin Structure Functions in the Resonance Region
E-01-109	C	Measurement of Gep/Gmp to Q2=9 GeV2 via Recoil Polarization
E-01-113	B	Deeply Virtual Compton Scattering with CLAS at 6 GeV
E-02-013	A	Measurement of the Neutron Electric Form Factor GEn at High Q^2
E-02-020	C	The Q(Weak) Experiment: A Search for Physics at the TeV Scale Via a Measurement of the Proton's Weak Charge

Properties of Nuclei

Exp. #	*Hall*	*Title*
☆E-89-003	A	Study of the Quasielastic (e,e'p) reaction in ^{16}O at High Recoil Momentum
★E-89-008	C	Inclusive Scattering for Nuclei at x>1 and High Q^2
★E-89-009	C	Investigation of the Spin Dependence of the ΛN Effective Interaction in the P Shell
☆E-89-015	B	Study of Coincidence Reactions in the Dip and Delta-Resonance Regions Resubmitted as PR-91-009
☆E-89-017	B	Electroexcitation of the Δ(1232) in Nuclei. Resubmitted as PR-91-009
☆E-89-027	B	Coincidence Reaction Studies with the CLAS
☆E-89-031	B	Study of Multi-Nucleon Knockout With the CEBAF Large Acceptance Spectrometer Resubmitted as PR-91-009
☆E-89-032	B	Study of the Local Properties of Nuclear Matter in Electron-Nucleus and Photon-Nucleus Interactions with Backward Particle Production Using the CLAS Detector -> PR-91-009
☆E-89-033	A	Measurement of Recoil Polarization in the ^{16}O (e,e'p) Reaction with 2.4 GeV Electrons
☆E-89-036	B	Study of Short-Range Properties of Nuclear Matter in Electron-Nucleus and Photon-Nucleus Interactions with Backward Particle Production using the CLAS Detector resub as PR-91-009
★E-91-013	C	The Energy Dependence of Nucleon Propagation in Nuclei as Measured in the (e,e'p) Reaction
☆E-93-008	B	Inclusive η Photoproduction in Nuclei
★E-93-019	B	Photoabsorption and Photofission of Nuclei
E-94-107	A	High Resolution Hypernuclear 1p shell Spectroscopy
★E-94-139	C	Measurement of the Nuclear Dependence and Momentum Transfer Dependence of Quasielastic (e,e'p) Scattering at Large Momentum Transfer
★E-97-006	C	Correlated Spectral Function and (e,e'p) Reaction Mechanism
★E-97-111	A	Systematic Probe of Short-Range Correlations via the Reaction ^{4}He(e,e'p)^{3}H
☆E-98-104	B	Measurement of the polarized electron beam asymmetry on exclusive reactions in nuclei with CLAS
★E-00-102	A	Testing the limits of the Single Particle Model in ^{16}O(e ep): An update to E89-003
E-01-011	C	Spectroscopic Study of Lambda Hypernuclei Up To Medium-Heacy Mass Region Through the (e,e'k+) Reaction
E-01-015	A	Update to E97-106: Studying the Internal Small-Distance Structure of Nuclei via the Triple Coincidence (e,e'p+N) Measurement
E-01-016	A	Precision Measurement of Longitudinal and Transverse Response Functions of Quasi-Elastic Electron Scattering in the Momentum Transfer Range $0.55\ \mathrm{GeV/c}<\lvert q\rvert<1.0\ \mathrm{GeV/c}$
E-02-017	C	Status of the ΛS=1 Hadronic Weak Interaction Program (update to 99-003)
E-02-019	C	Inclusive Scattering from Nuclei at x>1 and High Q2 with a 6 GeV Beam

Strange Quarks

Exp. #	*Hall*	*Title*
★/E-89-004	B	Electromagnetic Production of Hyperons
★/E-89-024	B	Radiative Decays of the Low-Lying Hyperons With PR-89-004
☆E-89-043	B	Measurements of the Electroproduction of the λ (gnd), λ*(1520) and $f_o(975)$ via the K^+ K^- p an
★/E-89-045	B	Study of Kaon Photoproduction on Deuterium
★E-91-010	A	Parity Violation in Elastic Scattering From the Proton and ^{4}He
☆E-91-014	B	Quasi-Free Strangeness Production in Nuclei
★E-91-016	C	Electroproduction of Kaons and Light Hypernuclei
☆E-93-022	B	Measurement of the Polarization of the ϕ(1020) in Electroproduction
☆E-93-030	B	Measurement of the Structure Functions for Kaon Electroproduction
☆E-95-003	B	Measurement of Kzero Electroproduction
★E-98-108	A	Electroproduction of Kaons up to Q^2=3 (GeV/c)^2
☆E-98-109	B	Photoproduction of phi Mesons with Linearly Polarized Photons
☆E-99-006	B	Polarization observables in the ^{1}H (e,e'K^+)Λ Reaction
E-99-115	A	Constraining the Nucleon Strangeness Radius in Parity Violating Electron Scattering
E-00-006	C	G^0 Experiment: Forward Angle Measurements
★E-00-112	B	Exclusive Kaon Electroproduction in Hall B at 6 GeV
E-00-114	A	Parity Violation from ^{4}He at Low Q^2: A Clean Measurement of ρ_s

Table VI-5
U.S. Institutions with Researchers on Experiments at Jefferson Lab

Abilene Christian University, Abilene, TX
American University, Washington, DC
Argonne National Laboratory, Argonne, IL
Arizona State University, Tempe, AZ
Boston University, Boston, MA
Brookhaven National Laboratory, Upton, NY
California Institute of Technology, Pasadena, CA
California State University, Los Angeles, CA
Carnegie Mellon University, Pittsburgh, PA
Catholic University of America, Washington, DC
Christopher Newport University, Newport News, VA
City College of New York, New York, NY
Duke University, Durham, NC
Eastern Kentucky University, Richmond, KY
Florida International University, Miami, FL
Florida State University, Tallahassee, FL
George Mason University, Fairfax, VA
George Washington University, Washington, DC
Georgetown University, Washington, DC
Gettysburg College, Gettysburg, PA
Hampton University, Hampton, VA
Harvard University, Cambridge, MA
Indiana University, Bloomington, IN
Indiana Univ. Cyclotron Facility, Bloomington, IN
James Madison University, Harrisonburg, VA
Kansas State University, Manhattan, KS
Kent State University, Kent, OH
Lawrence Berkeley Laboratory, Berkeley, CA
Los Alamos National Laboratory, Los Alamos, NM
Louisiana Tech University, Ruston, LA
Mass. Institute of Technology, Cambridge, MA
Mississippi State University, Mississippi State, MS
MIT Bates Linear Accelerator, Middleton, MA
MITI, Median Par kWay, Durham, NC
NIST, Gaithersburg, MD
National Science Foundation, Washington, DC
New Mexico State University, Las Cruces, NM
Norfolk State University, Norfolk, VA
North Carolina A & T St. Univ., Greensboro, NC
North Carolina Central University, Durham, NC
North Carolina State University, Raleigh, NC
Northeastern University, Boston, MA
Northwestern University, Evanston, IL
Ohio State University, Mansfield, OH
Ohio University, Athens, OH
Old Dominion University, Norfolk, VA
Oregon State University, Corvallis, OR
Pacific Northwest Laboratory, Richland, WA
Pennsylvania State University, State College, PA
Phillips Geophysical Laboratory, Lexington, MA
Princeton University, Princeton, NJ
Quantum Design/Quantum Magnetics, San Diego, CA
Renaissance Technology, Stony Brook, NY
Rensselaer Polytechnic Institute, Troy, NY
Rice University, Houston, TX
Rutgers University, New Brunswick, NJ
Southern Univ. at New Orleans, New Orleans, LA
Stanford Linear Accelerator Center, Stanford, CA
Stanford University, Stanford, CA
Syracuse University, Syracuse, NY
Temple University, Philadelphia, PA
Texas A&M University, College Station, TX
The College of William and Mary, Williamsburg, VA
Jefferson Lab, Newport News, VA
Triangle Univ. Nuclear Laboratory, Durham, NC
University of California, Los Angeles, CA
University of Colorado, Boulder, CO
University of Connecticut, Storrs, CT
University of Georgia, Athens, GA
University of Houston, Houston, TX
University of Idaho, Moscow, ID
University of Illinois, Urbana-Champaign, IL
University of Kansas, Lawrence, KS
University of Kentucky, Lexington, KY
University of Maryland, College Park, MD
University of Massachusetts, Amherst, MA
University of Michigan, Ann Arbor, MI
University of Minnesota, Minneapolis, MN
University of Mississippi, University, MS
University of New Hampshire, Durham, NH
University of North Carolina, Chapel Hill, NC
University of Notre Dame, Notre Dame, IN
University of Pennsylvania, Philadelphia, PA
University of Pittsburgh, Pittsburgh, PA
University of Richmond, Richmond, VA
University of Rochester, Rochester, NY
University of South Carolina, Columbia, SC
University of Southern California, Los Angeles, CA
University of Texas, El Paso, TX
University of Virginia, Charlottesville, VA
University of Washington, Seattle, WA
University of Wisconsin, Madison, WI
University of Texas, Houston, TX
Virginia Poly. Inst. & State Univ., Blacksburg, VA
Virginia State University, Petersburg, VA
Western Kentucky University, Bowling Green, KY

Table VI-6
Foreign Institutions with Researchers on Experiments at Jefferson Lab

Country	Institution Name
ARMENIA	Yerevan Physics Institute, Yerevan, Armenia
AUSTRALIA	University of Adelaide, Adelaide, Australia
BELGIUM	Ghent State University, Ghent, Belgium
BRAZIL	University of Sao Paulo, Sao Paulo, Brazil
CANADA	Queen's University, Kingston, ON, Canada
	St. Mary’s University, Halifax, Nova Scotia, Canada
	TRIUMF, Vancouver, BC, Canada
	University of Northern British Columbia, Prince George, BC, Canada
	University of British Columbia, Vancouver, BC, Canada
	University of Manitoba, Winnipeg, Canada
	University of Regina, Regina, SK, Canada
	University of Saskatchewan, Saskatoon, SK, Canada
CHINA	China Institute of Atomic Energy, Beijing, China
	Peking University, Beijing, China
COLUMBIA	Universidad de los Andes, Columbia
CROATIA	Rudjer Boskovic Institute, Zagreb, Croatia
CZECHOSLOVAKIA	Nuclear Physics Institute, Prague, Czechoslovakia
FRANCE	Institut de Physique Nucleaire, Orsay, France
	Institut des Sciences Nucleaires, Grenoble, France
	DAPNIA, C. E. A. SACLAY, Gif-Sur-Yvette, France
	Universite Blaise Pascal, Aubiere, France
	Universite de Clermont-Ferrand, Clermont-Ferrand, France
GERMANY	Deutsches Elektronen Synchrotron, Hamburg, Germany
	Forschungszentrum Juelich Institut Fuer Kernphysik, Juelich, Germany
	Univ. of Tubingen, Tubingen, Germany
	Universitaet Giessen, Giessen, Germany
	Universitaet Mainz, Mainz, Germany
	Universitat Bonn, Bonn, Germany
GREECE	University of Athens, Athens, Greece
INDIA	Indian Institute of Technology, Kanpur, India
INDONESIA	University of Indonesia, Jakarta, Indonesia
ISRAEL	Birzeit University, Birzeit West Bank, Israel
	Racah Inst. of Physics, The Hebrew Univ., Jerusalem, Israel
	University of Tel Aviv, Israel
ITALY	INFN, Ferrara, Italy
	INFN/Bari, Bari. Italy
	INFN, Sezione Lecce, Lecce, Italy
	INFN/Sanita, Roma, Italy
	Istituto Nazionale di Fisica Nucleare, Genova, Italy
	Int. School Advanced Studies Sissa, Trieste-Miramare, Italy
	Lab. Naz. Frascati, Frascati, Italy
	Univ. Pisa, Pisa, Italy
	Univ. Roma II, Roma, Italy

Foreign Institutions with Researchers on Experiments at Jefferson Lab

Country	Institution Name
JAPAN	Oska Eectro-Commun. University, Osaka, Japan
	Osaka University, Osaka, Japan
	Shizuoka University, Shizuoka, Japan
	Tohoku University, Sendai, Japan
	Yamagata University, Yamagata, Japan
	Univ. of Tsukuba, Ibaraki, Japan
NETHERLANDS	NIKHEF, Amsterdam, The Netherlands
	Rijks Universiteit Utrecht, Utrecht, The Netherlands
	Vrije Universiteit, Amsterdam, The Netherlands
	University of Utrecht, Utrecht, The Netherlands
NORWAY	Norwegian Defense Research Establishment, Kjeller, Norway
POLAND	Jagellonian University, Krakow, Poland
ROMANIA	University of Bucharest, Bucharest, Romania
RUSSIA	Institute for High Energy Physics
	Budker Institute for Nuclear Physics, Novosibirsk
	Inst. for Theor. & Experimental Physics, Moscow, Russia
	Joint Institute For Nuclear Research, Moscow, Russia
	Nuclear Physics Institute, St. Petersburg, Russia
	Tomsk Polytechnical University, Tomsk, Russia
SOUTH AFRICA	University of South Africa, Pretoria, South Africa
	University of Stellenbosch, Stellenbosch, South Africa
SOUTH KOREA	Chungnam National University, Daejeon, Korea
	Kyungpook National University, Taegu, Korea
	Seoul National University, Seoul, Korea
	Yonsei University, Seoul, Korea
SPAIN	Universidad de Barcelona, Barcelona, Spain
	Universidad de Valencia, Valencia, Spain
SWEDEN	University of Lund, Lund Sweden
SWITZERLAND	University of Basel, Basel, Switzerland
UKRAINE	Institute for Physics and Technology, Kharkov, Ukraine
	Kharkov State University, Kharkov, Ukraine
UNITED KINGDOM	Glasgow University, Glasgow, Scotland

B. CEBAF Accelerator Operations

The mission of CEBAF accelerator operations is the delivery of electron beams meeting world-class standards and users' expectations to Jefferson Lab's three nuclear physics experimental halls. During the period covered by this Institutional Plan, accelerator operations will continually improve our capability to routinely deliver reliable, simultaneous beams to three halls with individually chosen energy and current, and with beam polarization available in at least two halls, and generally three.

Performance Objectives

The CEBAF accelerator's primary objective is to provide reliable user service with all the required beam properties: variable RF microstructure, energy, energy spread, current, emittance, polarization, and reproducibility. It is designed for continuous operation and is most productive when run for the longest period compatible with the accelerator's annual maintenance requirements (since the refrigerator must be operated with or without beam).

The primary short–term plans for enhancing the accelerator capabilities include:

- Steady improvements in the area of polarized beams, maintaining polarization at 75% or greater, with the capability of providing a total of up to 170 µA beam current to the Halls with acceptable cathode lifetime;
- Improvements to the multiple lasers used for independent operation of polarized beam to all three halls; and
- Operation with difference pulse structures.

A new beam envelope limiting system has been built to ensure that the beam parameters remain within the Operating Envelope.

Performance Enhancement

For accelerator operation, the most important figure of merit is the number of useful beam hours for physics data taking. To achieve the maximum number of beam hours, and meet user requests for higher energies, we plan for (based on funding requirements identified in Table IV-1):

- Running time to exceed 30 weeks per year (starting in FY2004) with one, two, and three-hall operation.
- Systematic efforts to raise the accelerator availability to 75% through reductions in failure rates, shortening of time to repair, and improved instrumental and procedural support of operators for faster tuning and recovery.
- In situ cryomodule rework/conditioning to deliver beams to experimenters at energies up to 6 GeV.
- Cryogenic plant work to maintain cw operations and end station refrigeration capability at full beam energy.

The accelerator availability and hall multiplicity goals through FY2007 are given in Table IV-1. Currently, the main limitations to high reliability are the RF systems and the RF trips due to cavity window arcing. The best way to operate is to try to run the accelerator for long periods, keeping the tunnel closed up as much as possible. This provides more accelerator operating weeks and tends to give higher availability. Our experience in this regard mirrors that of other laboratories.

Routine maintenance is scheduled after every major holiday if accelerator operations have been suspended, and this is expected to continue. Some accelerators operate on the principle of "perform maintenance only when something is broken" due to the difficulties involved with accelerator start-up. We intend to continue with scheduled maintenance, albeit with a frequency that may evolve over time, as the more predictable nature of this operating mode is preferable to our users. In addition, one half day a week is devoted to RF recovery to maintain the inventory of RF cavities as high as possible and/or to perform machine development to improve accelerator capability.

The main limitation to high hall multiplicity is the availability of manpower to stage experiments.

For example, every experiment would prefer to perform its annual major maintenance and large-scale new experiment installation during the annual accelerator shutdown. Efficient use of manpower, however, does not allow such peak efforts, and experiment installation must be staged sequentially. Additional staffing would improve the throughput and increase overall efficiency substantially.

Superconducting Radio Frequency (SRF) R&D

One of the Jefferson Lab's key competencies is in SRF technology. The application of this expertise has resulted in a gradual improvement of CEBAF energy from its design value of 4 GeV to routine operation at 5.8 GeV, and a 6 GeV demonstration. It is also being successfully applied to Jefferson Lab's second major program, the FEL. Additionally, a substantial amount of SRF R&D is now directed toward the CEBAF Energy Upgrade.

Design studies conducted in 1998 led to a baseline concept for the 12 GeV Energy Upgrade based on a 5.5-pass machine, and on the addition of new, higher-performance cryomodules and, possibly, the replacement of a few existing ones. This concept calls for cryomodules that, in the same length as the existing ones, will be capable of providing energy gains 4–5 times higher than the original CEBAF design with only a modest increase in the cryogenic losses. This will require the development of superconducting cavities operating at gradients of 19 MV/m and Q of 8×10^9, compared to 5 MV/m and 2.4×10^9 respectively for the CEBAF design. This R&D effort is progressing along four parallel tracks:

- Determination of the operational limits, and operation at those limits of the existing CEBAF cryomodules. This has resulted in a continuous improvement in the CEBAF maximum energy, and in a better understanding of the fundamental limitations of superconducting cavities in an operating accelerator. This activity was initiated in 1997 and is essentially complete.

- Upgrade and improvement of our processing and testing facilities, as well as development of new procedures related to chemical processing, cleaning, clean room techniques leading to a reduction in particulate contamination, and high-temperature treatment of superconducting cavities. Upgrade of our facilities started in 1998 and was completed in 2001.

- Development and demonstration of prototypes of the key components of the Upgrade cryomodule. A prototype cavity successfully met the upgrade requirements in 1998. Development of the prototype components will be completed in FY2002.

- Development of advanced control of microphonics in order to allow operation at high gradients and to reduce the rf power requirements. Experimental investigation of microphonics in the prototype SNS cavities were built and tested at Jefferson Lab in FY2002, and the feasibility of their control via piezoelectric timers currently under study at Jefferson Lab looks promising.

All the above R&D activities will converge in the installation of an Upgrade Cryomodule in the CEBAF North Linac in FY2004.

To capitalize on recent advances in SRF, a study was initiated in FY2001 to provide a cost-optimized path to the 12 GeV upgrade of the CEBAF accelerator. This study demonstrated that, while the performance goals of the components will need to be at the forefront of SRF technology and therefore will need some development, they are well within the capabilities of the Laboratory. In particular, this cost-optimized option calls for cavities operating at gradients above 19 MV/m and at Q_0 above 8×10^9, and driven by 13 kW klystrons. Electropolishing of the accelerating structures' interiors is at the heart of the new development. This procedure is so promising that it has been adopted by the SNS project as its baseline. Likewise, the 12 GeV upgrade has adopted it in the last year. As the performance goals for the 12 GeV upgrade exceed those for SNS, some development will be done during the construction of two additional prototypes, one for the FEL program in FY2003 and one that will be used to replace a problematic existing cryomodule in

CEBAF in FY2004. The latter unit will be the final prototype with performance goals as described above.

In addition, a modest long-term R&D effort is directed toward challenging the assumptions that went into the selection of the baseline concept. This could result in additional options for the 12 or 24 GeV Upgrade programs.

C. Free-Electron Laser (FEL)

The Jefferson Lab FEL Program developed from the Laboratory's desire to exploit its unique core competency in SRF accelerator technology. SRF's capability to produce electron beams with high beam quality and high average power—two essential characteristics of CEBAF accelerator beams—afforded the opportunity to design SRF-accelerator-driven FELs as high-average-power light sources. In 1991, the Laboratory formed an Industrial Advisory Board with scientists selected from major industrial research laboratories to explore the potential opportunities and requirements for SRF-driven FELs as unique tools for advanced manufacturing based on the laser processing of materials. In 1993, the group of stakeholders for the FEL Program was enlarged with the formation of the Laser Processing Consortium, which included a group of SURA universities and the Naval Post Graduate School. Specifications were developed for the design and implementation of a kilowatt-level demonstration FEL, with output in both the IR and UV wavelength domains. Because of the synergy between identified industrial and defense applications of the proposed FELs, significant common specifications were developed. This commonality eventually led to the initial funding by the Office of Naval Research for the Jefferson Lab FEL Program in FY1996.

The construction of a 1-kilowatt demonstration FEL (the IR Demo FEL) and associated User Facility was completed in 1997 (Figure VI-4). First light was achieved on June 17, 1998 at power levels more than 14 times the previous world's record of 11 watts for FELs operating in the optical regime. Commissioning was completed in July of 1999, when an average power output of 1.72 kilowatts was achieved at 3.1 microns in the energy recovery mode.

With energy recovery, the electron beam current could be raised to 4.8 mA, even though there is only sufficient RF power installed in the device to support 1.1 mA of beam current in the non-recirculated mode. This achievement of significant energy recovery in a high power linac has ignited the scientific community's interest in the use of energy recovered linacs for the design of next generation high brilliance light sources for materials science and colliders for nuclear and particle physics. A device similar to the IR Demo is being constructed by Cornell University and several U.S. and European national laboratories are planning similar devices.

For the basic research community, SRF-driven FELs represent a natural extension in light-source technology that DOE has provided to the atomic physics, biophysics, chemical physics, and materials science communities: a factor of more than 10^5 increase in source brightness (at 0.1% bandwidth) in the infrared and the ultraviolet compared to the present generation of synchrotron light sources. For the industrial community, the high average power of an SRF FEL, and the broadband tunability and short pulse length for efficient coupling to materials, represent important advantages over conventional lasers for some materials processing applications. For both the industrial and defense communities, the possibility of extrapolating the FEL technology from the power level of the kilowatt IR Demo to much higher power systems (>100 kW) with lower net costs per unit of delivered power are significant design assets.

The first phase of the Jefferson Lab FEL Program began in June 1996 with the start of construction of the IR Demo FEL and the FEL User Facility on the CEBAF accelerator site. Construction was completed in September 1997, and commissioning was completed in 1999. The IR Demo FEL project was funded with support from ONR ($11.7M), the Commonwealth of Virginia ($5M), DOE ($5.5M for injector and cryomodule activities), and $3M from several industrial partners from the Laser Processing Consortium (LPC).

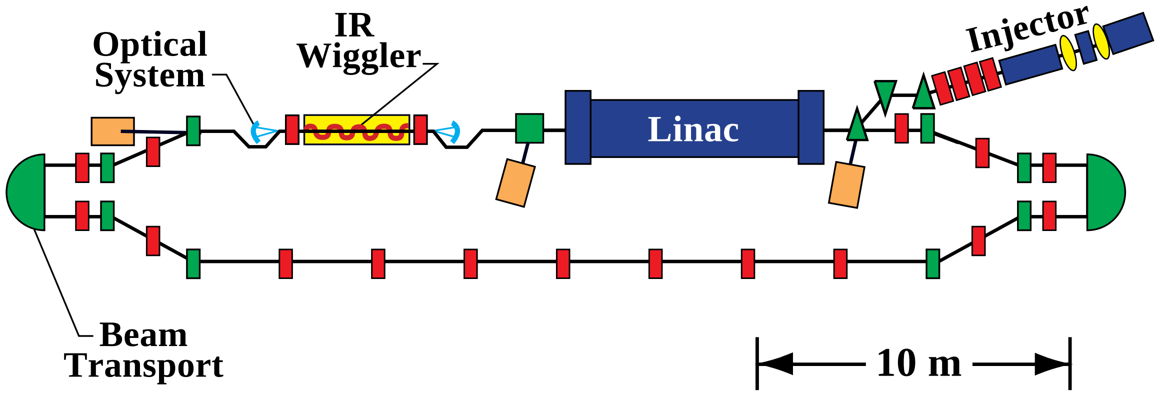


Figure VI-4: The Jefferson Lab IR Demo FEL

The FEL user program began in late 1999 following the completion of commissioning for both basic and applied science users of the FEL. Both user programs had their genesis in Laser Processing Consortium/FEL User workshops which are held annually (since 1994) to provide the Laboratory with guidance on the planning and implementation of the FEL Program and, specifically, for planning initial outfitting and use of the laboratories in the User Facility. LPC working groups on polymer processing and metal processing outfitted the first two FEL user laboratories in preparation for the first FEL user runs in 1999-2000. The FEL basic science user program was launched with a DOE Basic Energy Sciences sponsored review in February 1997 of the Jefferson Lab FEL Program to examine potential basic research applications of the facility. All of the identified industrial applications of the FEL bring with them basic research questions of interest to the scientific community such as fast linear dynamics and non-linear interactions of ultra short pulse laser light with matter. In addition, the unique properties of the FEL light (broad tunability, high average power and ultra short pulse structure) suggest forefront scientific experiments not possible with conventional lasers or other light sources. A User proposal process was initiated at the June 1997 Laser Processing Consortium/FEL Users workshop and this has continued through succeeding LPC/FEL User Workshops. This process was formalized in 2000 with the formation of the FEL Program Advisory Committee (PAC). Proposal solicitation and peer review by the PAC was followed for the FEL user runs scheduled in 2001-2002 prior to the shut-down of the machine to allow installation of the FEL upgrade. Selected proposals led to executed user experiments involving: (1) atomic, molecular and optical physics; (2) chemical physics; (3) materials physics; and (4) biophysics.

The second phase of the FEL program began in June 2000 with the start of the FEL Upgrade project. With $16.4M of funding provided by ONR in FY2000-2002, Jefferson Lab is designing and fabricating an upgrade to the IR Demo FEL that will increase the optical power output in the infrared to over 10 kW when the upgrade is commissioned in FY2003. In order to maximize the user time of the IR Demo, the installation of the upgrade hardware was delayed until December 2001. The IR Demo FEL upgrade is based on adding two cryomodules to the baseline FEL's SRF driver accelerator, extending its energy to 160 - 200 MeV by using prototypes of the high gradient cryomodule developed for the CEBAF energy upgrade. An upgraded injector based on the design of the present FEL photocathode gun will provide twice the current (10mA) of the original design. A higher efficiency IR wiggler has already been developed with one of our industrial partners (Northrop Grumman) who collaborated with Jefferson Lab in the construction of the IR Demo. The higher energy linac (160-200MeV) being incorporated in the IR FEL Upgrade enabled a second cost-effective upgrade project which extends the kilowatt class operation of the device through the visible to the ultraviolet (300nm) portion of the spectrum. This project, which adds a UV wiggler/optical cavity and UV transport hardware to the FEL Facility, was developed jointly with the Aerospace Corporation, an LPC partner since 1994 involved in UV processing of materials for aerospace applications. Financial support ($4.3M of FY01-02 funds) was obtained through the Department of Air Force science agencies. Completion funding for the UV FEL project (approximately $3M) is anticipated in FY2003.

The arrival of the superconducting storage ring HELIOS-1 at the end of 2000 marked a significant extension of the program to develop advanced light sources at Jefferson Lab. The ultimate goal is to have synchronized pulses of synchrotron and FEL light for multi-wavelength dynamics experiments.

D. Spallation Neutron Source (SNS)/Rare Isotope Accelerator (RIA)

Since two of Jefferson Lab's core competencies are SRF and 2K refrigeration, we continue to be involved with a number of collaborations that require this expertise. These collaborations will permit us to maintain and upgrade our core competencies as well as transfer knowledge to other national laboratories and universities.

For the SNS project, Jefferson Lab is the lead partner for the refrigeration system and the cryomodules. The refrigeration system is a half-scale copy of the CEBAF system. The system has been fully contracted and deliveries will be complete this summer. Installation of the transfer lines started on April 1, 2002 and installation of the warm compressors began in June 2002, long before we were to get beneficial occupancy of the buildings.

The SNS cryomodules required a two-year R&D program followed by two and a half years of construction and commissioning. We have built and tested cavities of both betas, 0.61 and 0.81, have completed both cryomodule designs, and have assembled and successfully tested the prototype cryomodule. A follow-on R&D program to increase gradients and reduce costs, ending one and one-quarter years after the first, is now in full gear, with the primary hardware having been delivered.

In order to reduce cost, the RIA project has decided to use the same frequency as SNS and therefore the same two highest-beta cavities in the driver linac. In FY2001, R&D started on optimizing the RF system controls to allow for much higher Q_{ext} and therefore much lower capital RF investment as well as operating power costs. We have collaborated in a number of meeting and workshops, helped with cost estimates, and helped build prototype beta 0.47 cavities. Some microphonic tests were made on the SNS prototype cryomodule that have important relevance to the efficient CW control of RIA cavities.

2. INFRASTRUCTURE

A. Administrative Practices

Jefferson Lab's Administration Division continues to undertake initiatives that add value to the Laboratory and are responsive to the expressed needs of both internal and external customers. The 2002 Administrative Peer Review Panel confirmed this, agreeing with their predecessors that, "The quality of the support provided by the Administration Division continues to be exceptional."[1] Focusing on best practices and continuous improvement, we have leveraged our limited resources in support of Jefferson Lab's vision and goals and have maintained a notable research-to-support ratio of 3.6—up from 2.8 in 1995. While we believe that we are close to the optimal balance of administrative support to direct research dollars, we continue to monitor our performance and deliver cost effective services in support of Jefferson Lab's mission.

Performance-Based Contracting

Through our performance-based contract with DOE, we establish and commit to clear objectives and

[1] Administrative Peer Review of the Thomas Jefferson National Accelerator Facility, February 27-28, 2002

measurable goals that derive from Jefferson Lab's mission. These high-level objectives in turn comprise the source from which staff objectives flow, thereby ensuring that staff remain focused on work that is aligned with the Laboratory's purpose. Optimal performance by individuals, who are held accountable through management, contributes directly to achieving the Laboratory's goals. Thus the performance-based contract facilitates the self-assessment and performance management processes that engender continuous improvement at Jefferson Lab.

The framework within which our business and administrative functions are assessed is Section 6 of Appendix B of our contract. The evaluation is based on a key performance measure (an annual peer review by a panel of Chief-Administrative-Officer-equivalents from private industry, national laboratories, DOE, and the scientific community) along with a set of secondary measures. The peer review process, supplemented by the DOE Site Office's ongoing operational awareness, has been determined by DOE to be an innovative and effective approach for reviewing and improving business and administrative performance. Our overall FY2001 assessment resulted in a rating of 93.5 out of 100 points for an adjectival rating of *Outstanding* in Business and Administrative Practices. Table VI-7 shows these results as well as the results of the FY2001 and FY2002 Administrative Peer Reviews.

Administration Division Office

The Administration Division Office is responsible for guiding and directing the Division, which includes Business Services, Human Resources and Services, and Plant Engineering, toward fulfillment of Jefferson Lab's mission. In addition to providing leadership and coordinating Division initiatives, the Division Office works to ensure that Department activities are in concert with the Laboratory's programmatic goals. It endeavors to secure required resources through the Laboratory's budgeting process, reports and negotiates contract performance metrics, performs quality assurance (QA), and facilitates both continuous process improvement throughout the Division and communication with other Divisions. In addition, line managers in each of the departments are responsible for integrated safety and security management, and the Division Office oversees these efforts.

Management Information Systems

In management information systems (MIS), we have developed cost-effective MIS support for administrative processes and improvement initiatives. The system is based on central, site-wide, internally accessible information and data to support decision-making and daily operations. It includes information on Laboratory population, finance, budget, time reporting, buildings and building access, mail stops, telephones, property, purchases and deliveries, on-line procurements, computer system access, material safety data sheets, training, Laboratory conferences, library holdings, and staff publications. Several web-based applications introduced within the past year are the enhanced financial and budget reports, the over two million items on-line for procurement in a business-to-business model, the on-line publications and publications approval system, on-line safety and security training and testing, travel requests, and logging of credit card transactions.

In the future, we will continue to migrate all multi-user MIS applications to the Laboratory's intranet using web technologies. Examples include the electronic (though not currently web-based) time reporting, key and property management, and people location applications. In addition we will be creating new web-based applications for the paper and spreadsheet based travel expense system, facilities maintenance system, space management activities, and tracking electronic signatures. We are currently implementing applicant tracking and on-line benefits systems as components of a Human Resources Information System (HRIS).

Table VI-7
Peer Review Results

KEY MEASURE: PEER	**FY01**			**FY02**		
	Available Points	**Points Achieved**	**Adjectival Rating**	**Available Points**	**Points Achieved**	**Adjectival Rating**
Division Office	10	9.5	Outstanding	10	9.5	Outstanding
Business Services	20	19.3	Outstanding	20	19.5	Outstanding
Human Resources & Services	20	17.5	Excellent	20	18.5	Outstanding
Plant Engineering	20	18	Outstanding	20	19	Outstanding
Public Information	Not reviewed as part of Admin Peer Review; addressed in Institutional Management Review			Not reviewed as part of Admin Peer Review; addressed in Institutional Management Review		
Information Resource Management	Reviewed as part of HR&S above			Reviewed as part of HR&S above		
Total Peer Review	**70**	**64.3**	**Outstanding**	**70**	**66.5**	**Outstanding**
SECONDARY MEASURES	**Available Points**	**Points Achieved**	**Adjectival Rating**	**Available Points**	***Points Achieved**	***Adjectival Rating**
Facilities Management	6	6	Outstanding	6	6	Outstanding
Property Management & Protection	5	5	Outstanding	5	5	Outstanding
Financial Management	6	6	Outstanding	6	6	Outstanding
Procurement	6	5.3	Outstanding	6	6	Outstanding
Human Resources & Services	6	5.5	Outstanding	6	5.7	Outstanding
Cyber Security	1	1	n/a	1	1	Outstanding
Total Secondary Measures	**30**	**28.8**	**Outstanding**	**30**	**29.7**	**Outstanding**
TOTAL: SECTION 6	**100**	**93.1**	**Outstanding**	**100**	**96.2**	**Outstanding**

* Points achieved and adjectival rating are projected based on mid-year results.

Future Improvement Goals and Initiatives

Administrative practices at Jefferson Lab continue to focus on high-value, cost-effective performance results monitored through a strong and well-established self-assessment program. The high level goals and initiatives listed below are supplemented by the more detailed ones presented in the subsequent administrative functional area descriptions.

- People — A comprehensive approach for attracting, compensating, developing, and retaining a quality workforce will be propagated Laboratory-wide. Areas of current and planned focus include the performance appraisal system, effective team, career, and management development, and succession planning.

- Processes — Modern information technologies and process improvements are being applied to publication approvals, space and storage management, on-site deliveries, telephone usage and systems, travel requests and expenses, human resources information systems, and business-to-business applications (two million items on-line to date) to name a few. In all cases, the metric employed is that there must be a clear benefit to the Laboratory's programmatic activities and goals as well as a cost benefit.

- Facilities — The Strategic Facilities Plan prepared in FY2000 and revised this year lays out a programmatically driven ten-year plan for maintenance and upgrades of existing facilities, removal of some older facilities, and construction of new facilities. The goal is to aggressively implement this plan consistent with the on-going evolution of the programmatic activities at Jefferson Lab.

B. Human Capital

The Human Resources and Services (HR&S) team is fully integrated with Jefferson Lab's mission and committed to providing quality customer service based on expertise, innovation and integrity. The HR&S department supports Jefferson Lab's programmatic initiatives through a variety of functional units including employment, compensation and benefits, employee relations, training and performance, staff services, the SURA residence facility, and information resources.

HR&S, in partnership with the Laboratory's senior management team, has taken a comprehensive approach to meeting the needs of the employee while simultaneously meeting the programmatic needs of Jefferson Lab. To that end, HR&S continuously creates, enhances and evaluates programs that assist in attracting, compensating, developing, and retaining a quality workforce.

In FY2002, we continue to focus on the Laboratory's performance appraisal system, career and management development, and succession planning. Working closely with the Laboratory Director's Council and other key staff members, HR&S developed a more user-friendly, objectives based performance appraisal system, and implemented Phase One in 2001. The new system forms the foundation for enhancements to career and management development through continuous feedback, training, and other tools, as well as for formalized succession planning. Building on this foundation, the Accelerator Division plans to pilot a succession-planning program during 2002-2003.

Advances in technology (a new HRIS that integrates with the Laboratory's financial systems and a new applicant tracking system) will increase our effectiveness and efficiency as well as expand services provided.

Staff Services continues to provide comprehensive logistical support services for conferences, meetings, and special events while managing food service operations. The SURA Residence Facility provides comfortable, attractive, hotel-like accommodations for staff, users, and visitors to the Laboratory. Information Resources oversees the Laboratory's Library, records management, and publications.

Laboratory Personnel

The success of Jefferson Lab's scientific program depends on its ability to attract and retain a diverse world-class workforce. As of September 30, 2001, the SURA/Jefferson Lab workforce was comprised of 601 employees plus 16 Commonwealth of Virginia employees. Table VI-8 shows full and part-time Laboratory staff composition. Between the end of FY2000 and the end of FY2001, the percentage of staff with Ph.D.s, master's degrees, or bachelor's degrees increased from 55% to 56%.

Jefferson Lab is a relatively small laboratory with many one-of-a-kind positions. This creates the staffing challenges of recruiting, selecting, and retaining individuals with highly specialized scientific, technical and managerial skills. The Laboratory maintains an international recruiting program utilizing professional conferences, collaborative working arrangements, scientific and technical journals, and university contacts as a means of identifying potential candidates for key positions.

The Laboratory also has programs to train, update, and enhance the capabilities of existing staff. These programs include on-site courses (classroom and CBT), on-the-job training, attendance at professional conferences and workshops, skill-enhancement training, and specialized training. Tuition assistance is available for employees in job-related degree programs.

Affirmative Action and Equal Employment Opportunity

Jefferson Lab values and encourages the individual uniqueness and differences that a diverse workforce provides. To create a diverse culture, the Laboratory continuously strives to expand recruiting efforts to include international recruiting, partnerships with Historically Black Colleges and Universities (HBCUs) and Hispanic Speaking Institutions (HSIs), direct recruiting through a variety of minority publications and web sites, participation in minority-targeted career fairs, and personal networks within influential minority organizations.

The Affirmative Action Profile (Tables VI-9 and VI-10) shows that Jefferson Lab staff increased by 6.6% from the end of FY2000 to the end of FY2001. During this period, the number of minority staff increased from 95 to 105 (10.5%) and the number of females increased from 153 to 169 (10.5%). HR&S and Jefferson Lab management are focused on continuous improvement in identifying and hiring additional minority staff.

Future Improvement Goals and Initiatives

- Complete implementation of the HRIS and the Applicant Tracking System.
- Recommend additional enhancements to the Performance Appraisal System and other avenues for providing feedback in support of a fully integrated communication, appraisal, staff development and succession planning process.
- Meet hiring/promotion/retention goals in Affirmative Action job groups currently underutilized and increase the number of minorities and females in the Jefferson Lab workforce.
- Continue working toward full partnership with the Laboratory's staff in attaining programmatic goals with talented, productive employees in a satisfying, high-morale environment.

Table VI-8
Laboratory Staff Composition
As of September 30, 2001
(Highest Degree)

Occupational Codes	Total #	Ph.D # (%)	MS/MA # (%)	BS/BA # (%)	AS/AA # (%)	Other # (%)
Professional Staff						
Scientists	125	85 (68%)	12 (10%)	26 (21%)	1 (1%)	1 (1%)
Engineers	136	1 (1%)	31 (23%)	43 (32%)	24 (18%)	37 (27%)
Mgmt & Admin	121	29 (24%)	31 (26%)	41 (34%)	9 (7%)	11 (9%)
Support Staff						
Technicians	141	0 (0%)	5 (4%)	25 (18%)	43 (30%)	68 (48%)
All Others	78	0 (0%)	0 (0%)	7 (9%)	12 (15%)	59 (76%)
Totals	**601**	**115 (19.1%)**	**79 (13.1%)**	**142 (23.6%)**	**89 (14.8%)**	**172 (29.3%)**

Note: Regular and term lab employees and SURA employees are included in Tables VI-8, VI-9 and VI-10.
Students, casuals, state employees and contract labor are excluded from Tables VI-8, VI-9 and VI-10.

Table VI-9
Affirmative Action Profile
Full and Part-time Employees (Jefferson Lab and SURA)
as of end of FY2000 (9/30/00)

Occupational Codes	Total		Minority Total		White		Black		Hispanic		Native American		Asian/Pacif. Islander	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Professional Staff														
Scientists/ Engineers	221 (88%)	30 (12%)	33 (13%)	4 (2%)	188 (75%)	26 (10%)	8 (3%)	2 (1%)	5 (2%)	0 (0%)	0 (0%)	0 (0%)	20 (8%)	2 (1%)
Mgmt & Admin	63 (62%)	39 (38%)	4 (4%)	5 (5%)	59 (58%)	34 (33%)	1 (1%)	4 (4%)	2 (2%)	0 (0%)	0 (0%)	0 (0%)	1 (1%)	1 (1%)
Support Staff														
Technicians	108 (80%)	27 (20%)	20 (15%)	5 (4%)	88 (65%)	22 (16%)	14 (10%)	4 (3%)	3 (2%)	0 (0%)	0 (0%)	0 (0%)	3 (2%)	1 (1%)
All Other	19 (25%)	57 (75%)	5 (7%)	19 (25%)	14 (18%)	38 (50%)	5 (7%)	19 (25%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Totals	411 (73%)	153 (27%)	62 (11%)	33 (6%)	349 (62%)	120 (21%)	28 (5%)	29 (5%)	10 (2%)	0 (0%)	0 (0%)	0 (0%)	24 (4%)	4 (1%)

Table VI-10
Affirmative Action Profile
Full and Part-time Employees (Jefferson Lab and SURA)
as of end of FY2001 (9/30/01)

Occupational Codes	Total		Minority Total		White		Black		Hispanic		Native American		Asian/Pacif. Islander	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Professional Staff														
Scientists/ Engineers	226 (87%)	35 (13%)	36((14%)	5 (2%)	190 (73%)	30 (11%)	10 (4%)	3 (1%)	5 (2%)	0 (0%)	1 (0%)	0 (0%)	20 (8%)	2 (1%)
Mgmt & Admin	71 (59%)	50 (41%)	8 (7%)	7 (6%)	63 (52%)	43 (36%)	1 (1%)	6 (5%)	3 (2%)	0 (0%)	0 (0%)	0 (0%)	3 (2%)	1 (1%)
Support Staff														
Technicians	115 (82%)	26 (18%)	22 (16%)	5 (4%)	93 (66%)	21 (15%)	16 (11%)	3 (2%)	3 (2%)	1 (1%)	0 (0%)	0 (0%)	3 (2%)	1 (1%)
All Other	20 (26%)	58 (74%)	5 (6%)	17 (22%)	15 (19%)	41 (53%)	5 (6%)	17 (22%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Totals	432 (72%)	169 (28%)	71 (12%)	34 (6%)	361 (60%)	135 (22%)	32 (5%)	29 (5%)	11 (2%)	1 (0%)	1 (0%)	0 (0%)	26 (4%)	4 (1%)

C. Business Services

The Business Services Department plays a strategic role to ensure that business processes and systems are in place to serve the needs of the Laboratory staff and scientific community. An important part of this responsibility is to provide effective and efficient procurement (see Table VI-11) and financial services through the use of sound internal controls and performance based methodologies that lead to innovative best-in-class business practices. Some examples of these business practices include: a proactive socioeconomic procurement program (see Table VI-12) that has received numerous awards from the DOE; expansion and enhancement of the web-based financial reporting system for site wide use; development and implementation of an on-line travel authorization request system; and the implementation of a web-based solicitations bulletin board to expand our Small Business outreach efforts and to reach a larger population of vendors.

Future Improvement Goals and Initiatives

Business Services' short term and long-term strategies for meeting our commitment to support the accomplishment of the Laboratory's mission and high-level objectives are outlined as follows:

<u>Near Term</u>

- Implement the second-generation on-line travel requisition system with electronic signature validation using the existing signature authorization database.
- Support the integration of Costpoint Payroll with HRIS.
- Review new Electronic Timesheet System options for possible upgrade.
- Lead the effort to develop and explore implementation of a new Web based Vendor File and Information System to significantly improve customer support and access to sources.
- Enhance the support of the Technology Transfer Manager and the Technology Review Committee through the development of enhanced tracking and reporting mechanisms.
- Continue to increase on-line access to financial and administrative services and resources.
- Enhance visibility of the site-wide recycle procurement program (Green purchasing) to promote purchases of recycled products.

<u>Long Term</u>

- Provide support and guidance in the exploration and implementation of an enhanced, Laboratory-wide budgeting system.
- Continue development of innovative opportunities that allow vendors to more effectively participate in our procurement process, e.g. the exploration of the Web for business functions and interactions.

Table VI-11
Subcontracting and Procurement

($ in Millions—Obligated)	FY2001	FY2002	FY2003
Subcontracting and Procurement from:			
Universities	2.7	2.8	2.8
All Others	45.5	41.2	44.7
Transfers to Other DOE Facilities	0.0	0.0	0.0
Total External Subcontracting and Procurements	**48.2**	**44.0**	**47.5**

Table VI-12
Small and Disadvantaged Business Procurement

($ in Millions—B/A)	FY2001 Goal	FY2001 Achieved	FY2002 Goal
Procurement from S&DB	4.1	3.0	2.2
Percent of Annual Procurement	7%	8.2%	6%

D. Environment, Health and Safety (EH&S)

EH&S Policies, Organization, and Management

Jefferson Lab utilizes line management to achieve environment, health, and safety (EH&S) goals and objectives. The Jefferson Lab Director has the ultimate responsibility and authority for the development, oversight, and implementation of EH&S policies. Fundamental to the Laboratory's EH&S Program is the commitment that line management bears primary responsibility for EH&S issues in line managers' areas of operation. Consequently, the EH&S effort is accomplished programmatically by line managers who have advisory input from EH&S staff distributed throughout the organization where their specific expertise is needed most.

Guidance for the implementation of EH&S policies is issued by the Directorate to the line divisions of Jefferson Lab via the *Jefferson Lab EH&S Manual*, available both on-line and in hard copy. The policies, procedures, and interfaces in the comprehensive EH&S Manual serve as the cornerstones of the Laboratory's Integrated Safety Management System (ISMS) Plan. Each line division takes full responsibility for the EH&S aspects of its operations and activities, including self-assessments. EH&S staff resources are positioned within the divisions for optimum alignment with operations. Institution-wide EH&S support, reporting, oversight activities, and internal appraisals are performed by the Office of Technical Performance.

Integrated Safety Management

Jefferson Lab, since its inception, has considered EH&S to be primarily a line management responsibility. The Laboratory's philosophy has been that it is a better use of resources to build EH&S into functional activities than to depend on audit or inspection for results.

The Jefferson Lab ISMS Plan provides a crosswalk between the DOE/SURA contract's ISM requirements and the Laboratory's directives and practices that implement ISM. A DOE Office of Science-led ISM Verification Review was conducted successfully in 1999 at Jefferson Lab. The ISM Review Team noted that the Laboratory's safety culture and program were extremely positive. The Office of Science chaired January 2002 Operations Review of the CEBAF also examined the implementation status of the Lab's ISMS. This review concluded that Jefferson Lab had satisfactorily implemented its ISMS. The ES&H portion of the Review's Closeout Report noted, "Jefferson Lab has a mature, integrated and cost effective safety program."

The Office of Technical Performance conducts an annual review and update of the Jefferson Lab ISMS Plan. An increased emphasis has been placed on the ISM feedback component. The increased use both internal and external lessons learned has improved ISM implementation in day-to-day work activities. A Jefferson Lab lessons learned web page has provided additional emphasis to the ISM feedback component.

Jefferson Lab Work Smart Standards Process

SURA, in cooperation with DOE, has carried out the "Work Smart Standards" (WSS) process, formerly called the "Necessary and Sufficient" process, for more effective EH&S management of Jefferson Lab. The goal of the WSS process at Jefferson Lab was to enable an EH&S system that is both effective and cost-efficient. It has identified the set of laws, regulations, and standards necessary and sufficient to ensure health and safety and to protect the environment.

SURA and DOE staffs work together in ongoing efforts to review the applicability of new or revised laws, regulations, standards, and DOE guidance documents. The WSS Set was most recently amended in March 2001. Joint SURA/DOE working groups reviewed new DOE directives that may have applicability to Jefferson Lab activities. A notable example was the review and subsequent implementation of applicable requirements of the DOE radioactive waste order.

EH&S Performance Measures

Environment, health, and safety are important dimensions of SURA's performance-based contract with DOE for managing and operating Jefferson Lab. Objective performance measures have been identified for evaluating Jefferson Lab's EH&S performance. The DOE/SURA performance-based contract has two key and eight secondary EH&S performance measures. The two primary measures are SURA injury avoidance performance as measured by the DOE Injury Cost Index and environmental exceedance performance. The secondary performance measures include lost work day case rate, reportable radiation exposures, reportable hazardous substance exposures, material recycling effectiveness, hazardous/radioactive waste generation, and fire protection program effectiveness. Emergency management and radiation protection peer reviews are conducted in alternating years to measure the effectiveness of these two programs.

EH&S Plans

Jefferson Lab's ES&H Budget Formulation Submission (formerly called the DOE ES&H Management Plan) considers the areas of industrial hygiene, radiation protection, environmental coordination, fire protection, emergency preparedness, industrial safety, occupational medicine, and internal appraisal. The current Jefferson Lab plan was submitted to the DOE in March 2002. Since the site is relatively new, the ES&H Budget Formulation Submission is dominated by the conduct, documentation, and continuous improvement of programs in the discipline areas listed. There are no significant cleanup or remediation needs. All required permits are in place.

Jefferson Lab has produced an annual *Site Environmental Report* (SER) since 1993. This SER document is prepared to provide, to the DOE and the public, information on the level of radiological and non-radiological pollutants, if any, added to the environment as a result of activities at Jefferson Lab. The SER also describes environmental initiatives, assessments, and programs for each year.

Jefferson Lab Implementation of 10 CFR 835

Jefferson Lab has implemented the DOE radiation protection rule, 10 CFR Part 835, "Occupational Radiation Protection". Part 835 addresses worker safety in radiological activities. Jefferson Lab's *Radiation Protection Program* (RPP) *Plan* and 10 CFR 835 *Implementation Plan* provide a programmatic approach to both evaluation and implementation of the requirements of 10 CFR 835 for Jefferson Lab radiological activities. Both current documents have received DOE approval.

The 10 CFR Part 835 Rule was amended in December 1998. The Jefferson Lab RPP Plan was revised to reflect the rulemaking changes. Several 10 CFR 835 enforcement guidance supplements since 1999 have noted that 10 CFR 830.120 ("nuclear QA rule") requirements apply to all radiological activities unless specifically excluded. DOE enforcement staff has determined that Jefferson Lab and other program dedicated accelerator laboratories are specifically excluded by the Price-Anderson rule itself.

An August 2001 radiation protection event was reported to the DOE under 10 CFR 835. The event involved an unposted high radiation area in the Test Lab during SRF testing activities. No personnel exposure resulted from the brief duration event. The DOE Headquarters Office of Enforcement approved report closure in May 2002 with no further action.

E. Security, Intelligence and Nonproliferation

Jefferson Lab is a low-hazard, non-nuclear accelerator facility chartered to conduct unclassified research into the fundamental nature of matter. As such the Laboratory has no classified material, no special nuclear material, no biological select agents, and no facilities designated as critical to the national interest. The Laboratory is categorized as a “Property Protection Facility,” the lowest level of security considerations authorized at any DOE facility. The core technologies used to design and operate the accelerator and the FEL or those related to use of the electron beam for research are available in open literature and are not considered “sensitive” national security technologies. The Jefferson Lab Technology Review Committee (JLTRC) monitors activity (Cooperative Research and Development Agreements, Work For Others, and User Facility Agreements, etc.) which could potentially generate proprietary or “export control” sensitive information and technologies. This committee is chaired by the Technology Transfer Manager and includes members with technical, legal and procurement expertise. The JLTRC and Jefferson Lab management recognizes that naval and industrial interest in the FEL facility may lead to the development or use of sensitive technology or information at Jefferson Lab. Anticipating that possibility, the Jefferson Lab is implementing a “graded” approach to FEL security that includes a staffed security gate, building access control, and a separate experiment room access control system.

Jefferson Lab uses Integrated Security Management and an integrated system of security consisting of both a centralized element in its management structure and a decentralized element in the assignment of security as a line management responsibility. Security focuses on providing protection of personnel, property, and information (i.e., cyber, business and personnel sensitive).

The Laboratory Director has full responsibility for security at Jefferson Lab and meets quarterly with key security staff to discuss collaborative development of security policies. Implementation of security and counterintelligence has been delegated to the Associate Director for Administration. These closely related functions are managed centrally in the Plant Engineering Department, except for cyber security, which is managed by the Computer Center, and business and personnel sensitive information that is managed by the Business Services Director and Human Resources and Services Director respectively. Responsibilities for security and counterintelligence are clearly delineated in Jefferson Lab’s DOE approved Security, Personal Property Management, and Export Control Plans and the Cyber Security Protection Plan. Additionally, Jefferson Lab has a current DOE “Facility Approval and Registration of Activities.” “Foreign Ownership Control or Influence” determination is no longer applicable. Select contractor staff in leadership and management positions have DOE clearances sponsored by the Office of Science in order to share classified threat information.

A standard 9-foot chain link fence encloses the Accelerator, FEL, Experimental Halls and Central Helium Liquefier (CHL). These facilities are accessible only through a continuously staffed gate. Two roving patrols monitor the site 24-hours-a-day. The main “campus” is not fenced and is open during normal work hours. Buildings are locked or access controlled. After hours, locked gates block off all but the main entrance road.

Jefferson Lab has installed a personnel badging system, Central Alarm Notification System, to enhance our ability to provide access control for all entrances to and egresses from the Accelerator

Site, and access to the main buildings on the campus portion of the facility. This system is integrated with the Laboratory's central personnel and visitor databases.

Cyber Security

Jefferson Lab is designated as a fundamental research laboratory and as such engages in no classified or national security work. In order to fulfill its mission, the Laboratory has to provide straightforward access to its experimental data and computing resources to scientific collaborators both nationally and internationally. The cyber security program uses a layered approach, with strategies in place to protect the networks, provide intrusion detection, monitor and protect systems, and apply application level security as well as administrative measures. Network protection is based on a tiered model with a firewall protecting the campus network and includes protected enclaves of certain essential systems such as Business Services, HR&S, and Accelerator controls. The full cyber security program is detailed in the DOE approved Cyber Security Program Plan (CSPP). The Laboratory recently completed a peer review of its cyber security program and implementation. The review concluded that the program is of high quality and very effective in protecting against risks, as well as being appropriately structured for the Jefferson Lab research environment.

Cyber Security Responsibilities

The Laboratory uses Integrated Security Management practices with responsibility for cyber security resting ultimately with line management and end users. The implementation of the cyber security program is the responsibility of the Head of the Computer Center who reports to the Chief Information Officer and thus to the Laboratory Director in matters of security. Within the Computer Center there are two cyber security staff who implement the program and policies in conjunction with a team including representatives from all laboratory-computing groups. Incidents are reported direct to the Computer Incident Advisory Center and DOE by the Computer Center, as well as to management.

Cyber Security Projects

Cyber security is a continuously evolving activity. Projects that are currently in hand include implementing a recently procured upgrade to the site firewall and restructuring some of the protected networks. Implementation of Virtual Local Area Networks (VLANs) to provide further levels of manageability and isolation for certain network segments is also in hand. As the security environment evolves, of necessity the tools used for host monitoring and intrusion detection have to evolve and current projects include replacing some of that software, as well as the addition of new software to provide vulnerability scanning capabilities. During the coming year more effort will be focused on providing a more comprehensive training program for system administrators and in particular for users. It is essential that the program remain flexible to handle the ever-changing security environment.

F. Public Communications and Trust

Through a comprehensive, proactive public information program, Jefferson Lab actively maintains constructive and effective communication with the public using various vehicles. Whether through personal interactions in committee meetings, civic presentations, public forums such as a book lecture or the State Fair, Jefferson Lab staff enthusiastically promote the Laboratory and its activities.

The Laboratory enjoys a positive partnership with the City of Newport News. Over the years, the City has maintained it astute philosophy concerning Jefferson Lab's role in the community and continues to support the Laboratory and to advance its programs. Examples of the city's support range from funding most of the land on which the Laboratory is sited to building the Applied Research Center (ARC) and the residence facility where users and visitors are housed temporarily. To continue to develop this important relationship, Laboratory personnel serve on City committees in such diverse areas as economic development, education, transportation, emergency management and recycling. Additionally, Jefferson Lab participates in economic development prospective visits to help the city build interest in high technology companies.

This partnership extends to the City of Newport News police and fire protection departments. Jefferson Lab and the city host joint emergency drills to ensure that the City can respond to our unique circumstances. Tours are conducted regularly to keep city personnel well acquainted with the site as it evolves. The Laboratory hires off-duty police force and EMT personnel to staff our public Open House.

Various methods are employed to maintain constructive, effective communication with the general public in the local area. Jefferson Lab personnel regularly visit and host civic and social organizations, serving as guest speakers on Laboratory-related topics. We also conduct tours of the Laboratory for these groups. The Jefferson Lab Science Series, with its high school aged audience, is now in its eleventh year. This program brings enthusiastic, often high-profile scientists to Jefferson Lab to demonstrate interesting science. It is advertised in local newspapers, at local schools, and for the first time this year, to all science teachers region-wide. This year, the American Institute of Physics 2001 Science Writing Award winner, Marcia Bartusiak, came to Jefferson Lab to talk about her winning book, *Einstein's Unfinished Symphony*. The Science Series is videotaped by the local school system and is re-broadcast on the City's cable channel, further extending the reach of these outstanding programs. Videotapes of the programs can be borrowed by requesting them via the Lab's Web site. About 6-10 tapes per week are distributed around the country as a result of requests we receive. In addition, Laboratory personnel visit local schools to discuss high-technology jobs and careers. Jefferson Lab also hosts an Open House every two years; the next one is scheduled for 2003. In alternate years, we host a booth at the Virginia State Fair, where in September 2001, Laboratory staff interacted with over 200,000 visitors.

As an additional means of communicating with both technical and non-technical audiences, the Jefferson Lab Web site is an affordable and effective means of sharing information. It is a key component of the Laboratory's communication strategy for both internal and external audiences. The Jefferson Lab Web site promotes the Lab and enhances its image, serves as an information resource and effective channel for communication with scientific user communities, and aids in the education of the general public and potential users about the Laboratory's scientific program technological advances and science education activities.

The Jefferson Lab Web site recently was redesigned for two purposes: to enhance visual communication to generate continued interest and further promote the Laboratory; and to improve navigation, usability, and ease-of-use while maintaining continuity. Two noticeable features include the addition of photographs on all public pages to chronicle the events and activities that are important to the life of the Laboratory, and a new home page which now offers a means of prominently displaying timely or newsworthy information. New applications have been added to the Web site, including the Events At-A-Glance calendar—a one-stop-shop listing all Jefferson Lab events, and the Jefferson Lab Picture Exchange (JPIX)—a dynamic, searchable database of the Laboratory's favorite images used by magazines, newspapers, and scientists. Journalists can read press releases, sign up to be on the press release list, and see information specifically for them at the site's journalists' newsroom.

At the state, regional and local levels, Jefferson Lab personnel participate in economic and technology committees to reach yet a different community. The Laboratory's partnership with the Virginia Physics Consortium, a statewide consortium of physics Ph.D.-granting institutions, has led to Jefferson Lab being viewed as a responsible steward of allocated state funds. In part because of this reputation, the state continues to fund the research of four local universities in the ARC and to provide additional money for university researchers to lease Laboratory space. In addition to their contribution to the ARC, state and local governments have contributed over $40 million to Jefferson Lab in direct appropriations over the past ten years. Jefferson Lab also participates in the Virginia Research and Technology Advisory Commission (VRTAC), a Commonwealth of Virginia created commission to coordinate activities of member research institutions.

Finally, Jefferson Lab enjoys a good relationship with the local print and broadcast media. Reporters routinely interact with the Laboratory's public affairs staff and request information that can be used to generate news stories. The national press and Jefferson Lab also collaborate to educate the public about the importance of fundamental research. Public Affairs ensures the DOE is identified in news stories about Jefferson Lab. Laboratory scientists who have actual first-hand knowledge and who are gifted in communicating to diverse audiences provide science reporters with detailed information on scientific topics. These interactions have proven very successful and have led to more frequent articles in the press. An ongoing science communication committee at Jefferson Lab identifies potential science articles that can be used by the press.

G. Science Education Enhancement

In addition to its role in providing undergraduate and graduate students with research opportunities, Jefferson Lab has taken on two special roles in its community: partnerships with HBCUs and HSIs, and community outreach to local area public schools and citizens.

Historically Black Colleges and Universities (HBCU) and Hispanic Serving Institutions (HSI)

Jefferson Lab has taken the initiative to make HBCUs and HSIs a vital part of its university-based research community. As part of a joint-faculty program, new faculty members are appointed to local university positions on a permanent cost-shared basis with Jefferson Lab. Jefferson Lab agrees, in these cases, to reimburse the university for one-half of the salary and benefits of a faculty member. In return, the university agrees to release that faculty member to spend half time conducting research at Jefferson Lab under the supervision of a Jefferson Lab Group Leader. In a second program, Jefferson Lab pays a fraction of the salary and benefits of a new faculty member for a fixed short term (a "bridging" period). In return, the university releases this faculty member on a pro rata basis to devote time to Jefferson Lab programmatic activities (including equipment building, software development, and research). The university assumes full responsibility for this faculty member upon the expiration of the "bridge assignment."

Partnerships with local HBCUs were initiated in 1989 with Hampton University and in 1992 with Norfolk State University. Hampton University has added four new faculty members to its physics department, while Norfolk State University has added three new faculty members. These faculty members were hired on a long-term, cost-shared basis.

In addition to these local joint-faculty partnerships, Jefferson Lab has made bridging arrangements with non-local HBCUs and HSIs. Current partners include Florida International University (FIU), North Carolina Agricultural and Technical State University (NCA&T), North Carolina Central University (NCCU), and the University of Texas at El Paso (UTEP).

By any reasonable measure, these partnerships are extremely successful. As an example, under the Memorandum of Understanding signed in 1989, the Hampton University Department of Physics has grown from a small department with a master's degree program and a few students into a major international player in quark and nuclear physics. With the support of Jefferson Lab, the Hampton University group working at the Laboratory received a $10M grant from the National Science Foundation in 1991. Based on their outstanding performance, this grant was renewed in 2001 for a second ten-year term. In 1992, Hampton University was certified to grant doctoral degrees in physics, making it one of only three such HBCUs in the country. The university's experimentalists are leaders on research proposals that have been awarded one-third of the beam time in CEBAF's Hall C, where they have focused their program. In the fall of 1996, Hampton University became the first

HBCU ever to lead a major experiment at a national accelerator laboratory and currently, Hampton University joint faculty members are the spokespersons for eleven approved or conditionally approved experiments. The Hampton University Department of Physics has become a major center for education of the next generation of minority scientists and engineers. During the 2001-2002 academic year, the department had an enrollment of 17 undergraduates, four of whom received their undergraduate degrees in Physics during FY2002. Post-graduate studies in physics continue to be strong with 28 doctorate students and four MS students enrolled during the 2001-2002 academic year. Hampton University awarded four doctoral degrees and three MS degrees in physics in FY2002. Three of these degrees were awarded in the field of nuclear physics. Twelve of the remaining 25 graduate students are currently pursuing advanced degrees at Hampton University are active in the Jefferson Lab research program.

A second HBCU in the local area, NSU, has also benefited from its partnership with Jefferson Lab. Signed in 1993, the NSU agreement has resulted in three new joint faculty appointments in the University's Physics Department: two in nuclear and particle physics and one in FEL-related materials science. The Nuclear and Particle Physics Group at NSU has aggressively sought and received funds from outside sources to support its research. At its present level of funding and research activities in 2002, the NSU Nuclear and Particle Physics Group is able to support at least six undergraduates per year to work part-time on Jefferson Lab research as well as provide two full scholarships for the next three years to NSU students. In August of 1998, the Virginia's Secretary of Commerce and Trade awarded a $2 million grant to four local universities collaborating in the ARC at Jefferson Lab. One of the beneficiaries of this grant is NSU, a member of the Laser Processing Consortium (LPC). The LPC is an industry-led private/public partnership for advancing the use of light as a manufacturing and research tool using Jefferson Lab's FEL Facility.

In 1995, Jefferson Lab entered into bridged-type partnerships with two regional HBCUs located in North Carolina: NCA&T, located in Greensboro and NCCU, located in Durham. Both are experiencing successes comparable to Jefferson Lab's local area HBCUs. Since its partnership with Jefferson Lab, NCA&T established a physics graduate program and recently produced their first Master's student. In the spring of 2000, NCA&T bridged faculty members were successful in securing a DOE grant to cover student support as well as funds to begin covering their own summer research time at Jefferson Lab. The grant has made it possible for three NCA&T undergraduate and graduate students to be placed on-site to work on Hall C projects during the summers of 2001 and 2002. The two new bridged faculty positions created at NCCU also are fulfilling the purpose for which they were created. The NCCU physics program has successfully expanded its collaborations, academic programs and opportunities for students, as well as advanced the research program of Jefferson Lab. In addition, NCCU has recently demonstrated its continued commitment to expand its nuclear physics program by creating a new tenure track faculty position fully funded by the University. The new faculty member is engaged in Jefferson Lab-related research topics, including hadronic structure, nuclear few body computational physics, and experimental nuclear physics.

Similar successes also have occurred as a result of Jefferson Lab's three bridged-type partnerships with HSIs. The first agreement with an HSI was signed in 1993 at FIU. Since then, the FIU Physics Department has grown from 14 to 22 faculty members. In 1997, FIU received approval from the Florida Board of Regents for a Ph.D. program in Physics and in the fall of 1999, the doctoral program began receiving its first students. The FIU bridged faculty members have undertaken increasingly important leadership roles in several key experiments and have involved more than a dozen students in their work at Jefferson Lab. Recently, the FIU nuclear physics group received a large DOE grant. As a result, summer funding support to work at Jefferson Lab research for six of the eight bridged faculty members is now covered externally. In addition, an FIU post-doctoral fellow and Ph.D. student are now in residence full-time. In the spring of 1995, Jefferson Lab also entered into partnerships with NMSU and its sister university, UTEP. NMSU bridged faculty members have also been successful in securing grant funding and plan to place a post-doctoral fellow and graduate student on-site at Jefferson Lab to devote 100% of their time to experiments running in Hall C. Since 1995, a total of four doctoral degrees have been awarded to NMSU students performing research directly related to Jefferson Lab. The UTEP bridged faculty member immediately received a DOE research grant, with which he has begun a successful visiting nuclear physics scholar program at the University of Texas at El Paso. In addition, the UTEP chapter of the Society of Physics Students recently increased its outreach to the El Paso community by initiating an annual "Physics Circus." During the summer of 2000, more than a dozen UTEP undergraduate students arrived at Jefferson Lab for a weeklong visit that included seminars, tours, and exposure to local universities offering graduate degrees in Nuclear Physics. With his second, consecutive University Research Grant, the UTEP bridged faculty member continues to create opportunities for undergraduate and graduate students to spend time at Jefferson Lab performing research in Hall B. Such accomplishments do not occur overnight: five to ten years, as with Hampton University, are required to create a successful academic program. However, Jefferson Lab's other HBCU/HSI partners are also beginning to enjoy comparable successes both scientifically and in the training of the next generation of minority scientists and engineers.

Student Affairs Office

In 1997, The Jefferson Lab Student Affairs office was created. It was established to provide a central office for assistance to the work of students and their advisors in their research collaboration at Jefferson Lab.

The Jefferson Lab Student Affairs Office has the principal goal of enhancing Jefferson Lab's production of trained scientific and technical manpower. Among the programs established by this office are a series of monthly seminars given principally by graduate students to inform colleagues of their work and several summer lecture series on detector development, data analysis and computing to help initiate new students into nuclear research techniques.

In addition, this office supports graduate student activities directed toward recreation and leisure and informal gatherings intended to enhance student life at the Laboratory. Support for and encouragement of a graduate student association in also provided.

The Student Affairs Office supports specific programs intended to assist students presently underrepresented in scientific fields such as the Hampton University Graduate Studies (HUGS) Program and similar programs at HBCU and Minority Educational Institutions.

K-12 Education Enhancement

In partnership with the local school districts and the surrounding community, Jefferson Lab is committed to:

- Offering math and science programs to students, teachers, parents, and the general public through Jefferson Lab events and community partnerships.

- Providing Jefferson Lab-related resources for teachers and faculty.

- Providing a nurturing research environment for college students and teachers.

Jefferson Lab's resources for achieving these goals are its staff scientists and engineers. During FY2001, about 10,500 students and 750 teachers interacted with one or more Jefferson Lab staff members who shared their knowledge, experience, and enthusiasm. Currently, 32% of Jefferson Lab staff volunteer to support these programs.

The BEAMS – Becoming Enthusiastic About Math and Science – program brings classes of sixth, seventh, and eighth grade students and their teachers to Jefferson Lab for science and math activities.

The BEAMS program targets those middle schools in Newport News with the largest at-risk student populations. Through the BEAMS program, Jefferson Lab:

- Motivates students to continue learning.
- Provides teachers with educational tools based on the science and technology at Jefferson Lab.
- Provides an opportunity for parents to become involved with their children's education at a weekly BEAMS Family Night.
- Provides Jefferson Lab staff with a vehicle to share their experiences, expertise, and enthusiasm.

Since 1991, BEAMS has involved about 16,500 students and 385 teachers. Results from the on-going evaluation of BEAMS include: (1) students attending BEAMS are significantly more positive about science and school than students not attending; (2) teachers report that BEAMS increases their awareness of hands-on science activities, applications of math and science, and careers in math and science; and (3) parents report that the BEAMS program has a positive influence on their children. Preliminary results from Virginia standardized test scores show that BEAMS is helping close the disparity gap between traditionally low scoring schools and average scoring schools. Huntington Middle School, where students attend BEAMS in grades 6, 7, and 8, shows improvements in test scores from 1998 to 2001 of 29 percentage points in mathematics and 26 percentage points in science. Huntington Middle School's parent school division showed increases of 17 percentage points in mathematics and 13 percentage points in science.

The SUNBEAMS program, Students United with NASA Become Enthusiastic About Math and Science, a replica of Jefferson Lab's BEAMS program, at NASA-Goddard Space Flight Center continues to be successful. NASA-Goddard hosts twelve SUNBEAMS classes each year.

The Physics Enrichment for Science Teachers (PEST) program targets middle school science teachers. The goal of this program is to improve the quality of precollege education by enhancing the knowledge base of middle school science teachers. Teachers participate in a four-week physics course taught by local high school physics teachers and Jefferson Lab staff. Thirty-two teachers are expected to participate during the summer of 2002.

Other community-based partnerships include:

- Jefferson Lab's Physics Fest which brings more than 3000 students to Jefferson Lab annually for a two-hour field trip highlighting cryogenics demonstrations and career opportunities.
- DOE's Energy Research Undergraduate Laboratory Fellowship program: a ten-week summer fellowship at Jefferson Lab for undergraduate physics majors.
- Jefferson Lab's Science Series: a monthly program for the public showcasing a variety of topics.
- Cooperating Hampton Roads Organizations for Minorities in Engineering (CHROME): a program that sponsors school-based science and math clubs throughout southeast Virginia.
- Summer research internships for high school students.
- Jefferson Lab's Web site that provides science education materials and information to teachers (http://education.JLab.org).

Table VI-13
University and Science Education Program Participation

	FY2001			FY2002 (Projection)		
	Total	**Minorities**	**Women**	**Total**	**Minorities**	**Women**
PRE-COLLEGE PROGRAMS						
Student Programs						
BEAMS Partnership	1875	1387	955	1650	1280	825
High School Summer Internships	13	7	3	13	7	6
Science Series, CHROME, etc.	8000	.~4500	~4200	8000	.~4000	~4000
Teacher Programs						
Summer Teacher Participation	24	9	18	32	11	21
Other Teacher Assistance	700			700		
UNDERGRADUATE PROGRAMS						
Student Programs						
Undergrad Student Research	10	1	4	10	2	4
Technical Interns Supported by JLab	23	5	5	26	3	4
GRADUATE PROGRAMS						
Student Programs						
Lab-Funded Graduate Students	24	16	7	36	24	11
SURA/JLAB Graduate Fellowships	10	6	3	8	4	3
Other Graduate Students on-site in Research	118	31	21	105	33	19
POSTGRADUATE PROGRAMS						
Fellowships						
Lab-Funded Post-Doctoral Fellows	28	6	6	29	7	6
Other Post-Doctoral Fellows on-site in Research	29	9	4	25	7	5

Note: Minority women are counted in the "Minorities" column and the "Women" column in both years.

H. Technology Transfer

The Jefferson Lab Technology Transfer Program currently emphasizes technology development and transfer activities built upon two of the core competencies derived from our basic research mission: SRF technology and detector technology. Leveraging our core technologies in collaboration with industry, educational institutions, and other federal agencies enhances opportunities for commercialization of Jefferson Lab's federally funded research efforts.

Jefferson Lab's major technology transfer effort is in its role as the lead institution in the Laser Processing Consortium (LPC), our key link to industry. The LPC was established by Jefferson Lab's Industrial Advisory Board to develop and apply FEL technology. The FEL Program and the LPC are described in Section VI.1.C. This consortium meets annually to provide guidance on the planning and implementation of the FEL Program and to plan outfitting and use of the FEL User Facility application laboratories.

A second area of concentration for Jefferson Lab's technology transfer, medical imaging, derives from the Laboratory's core competency in detector technology. In a milestone achievement in 1996, Jefferson Lab negotiated a Cooperative Research and Development Agreement (CRADA) and awarded a license to a small business partner to jointly further the development of a scintimammography medical imaging device. This device, which is based on six Jefferson Lab patents and pending patents, has the potential for significant improvements in early breast cancer detection. This effort is being conducted jointly with partner research hospitals (at the University of Virginia Medical School, and, George Washington University Medical Center) and has won the recognition of the Women's Health Office of the Department of Health and Human Services. In 1999, the imaging device won Food and Drug Administration approval, and the first commercial product is being produced by our business partner, Dilon Technologies, Inc.

Another key partnership is the Laboratory's relationship with the City of Newport News. From the Lab's start in the 1980s, it has always received the city's generous support. With the realization that Jefferson Lab and its Technology Transfer Program could lead to increased economic development, the city completed building in 1998 a high profile, seven-story complex. This building, the Applied Research Center or ARC, houses Laboratory personnel, five local university R&D efforts, and key industry partners. The ARC is an $18.4 million investment that the city is using to jump-start a new 200-acre high-technology business park, the Jefferson Center for Research and Technology, which is adjacent to the Jefferson Lab campus. Jefferson Lab personnel have actively participated in the design and development of both the park and the ARC building. The City counts on this support for continuing efforts to strengthen and diversify the local economy. By 2001 the ARC building was fully occupied and fully functioning. To accommodate related activities, planning has begun for a second building to be built next to ARC when funding sources have been secured. In 2002, the first major commercial tenant for Jefferson Center, Symantec Corporation, completed a 100,000 sq. ft. building to house its mid-Atlantic headquarters.

Intellectual property management is a significant element of the Jefferson Lab Technology Transfer Program. Jefferson Lab's Technology Review Committee reviews and funds invention disclosure reviews, patent applications and related licensing actions. In addition, SURA established an oversight board that periodically reviews the committee's authorizations and activities. To date, Jefferson Lab has processed 119 invention disclosures, has received 29 patents and three licenses, and currently has 25 patent applications under active consideration.

I. Site, Facilities and Infrastructure Management

Site and Facilities Description

The Jefferson Lab site, located in Newport News, Virginia (Figure VI-5), includes 162 acres owned by the DOE and eight acres owned by the Commonwealth of Virginia. SURA owns 44 acres adjacent to the site. The facilities include the CEBAF accelerator complex serving three experimental halls, the FEL Facility, a central office building (CEBAF Center), two major laboratory buildings, and various other support structures totaling 675,961 sq ft (see Table VI-15).

Included are 50,211 square feet of office trailers and 19,120 square feet of storage containers. The replacement value of conventional facilities and utilities is $215 million (see Table VI-16). Figures VI-6 through VI-8 show age, condition, and use of space.

The accelerator enclosure is a 7/8-mile racetrack-shaped concrete tunnel located 25 feet underground. The tunnel houses a 65 MeV injector, two 600 MeV linacs—one in each straight section of the racetrack—and six kilometers of beam transport lines. The CHL, a 75,000 liquid liter, 4800-watt refrigerator plant located in the interior of the racetrack, supplies liquid helium at 2 K to the accelerator for the ultracold needed for superconducting operation. The Machine Control Center houses the computer systems that control and monitor accelerator operations. The FEL generates high power infrared light using the accelerator technology, and shares the CHL.

The experiment area consists of three large domed concrete halls, partially underground and mounded with earth for shielding. The floors are about 36 feet below existing grade, and the domes extend up to 45 feet above grade. Hall A is 174 feet in diameter, Hall B 98 feet, and Hall C 150 feet. The major support building for the experimental physics area is the Counting House, where physicists control and monitor the experimental runs. Some 35 support structures in the accelerator/experimental area complement these major structures.

Major structures on the remainder of the site provide administrative space, as well as laboratory and technical support facilities. CEBAF Center provides office space, an auditorium, and a cafeteria, and houses the computer center. The Experimental Equipment Laboratory (EEL) provides light laboratory space for detector fabrication and machine shops. The Test Lab is a high-bay building housing major component assembly, test, and maintenance functions.
The City of Newport News has constructed the ARC building on an 11-acre site directly adjacent to the Laboratory. The 121,000 sq ft structure, completed in the spring of 1998, provides office and light laboratory space for lease to qualified tenants. Jefferson Lab has leased 42,492 sq ft. Five local collaborating universities also have leased space. The ARC is the anchor for the city's planned 200-acre Jefferson Center for Research and Technology, a technology park for high technology R&D and production activities.

The Plant Engineering Department manages a facilities condition assessment program that utilizes a multidisciplinary team including an architect, engineers, EH&S personnel, and building occupants to evaluate the functional condition and maintenance needs of each facility. These evaluations are performed on a three-year cycle. Results of the assessment are prioritized and either handled as a corrective work request or programmed for future General Plant Projects (GPP) funding. This condition assessment program is in its second year of use. The overall condition of the buildings, utilities, and other structures is adequate; however the size of the maintenance backlog (deferred maintenance) is growing. For example, the low conductivity water system usage has reached the limits of its current capacity and there is a need to install additional emergency generator capacity. There are currently no excess facilities.

Site and Facilities Trends

The following is a summary of the facilities changes that have occurred over the last two years:

Change in total square footage:	
Test Lab Addition:	+12,355 sq ft
Change in number of trailers:	+ 0 sq ft
Change in storage containers:	+ 640 sq ft
Change in space leased of site:	+ 2,662 sq ft

In FY2001 the annual maintenance requirement was over $2.8 million and was less than needed to keep the Laboratory's conventional facilities sound and capable of supporting operational requirements for the long term. This amounted to about 1.3% of the Replacement Plant Value of the facilities (buildings, utilities, roadways). Actual maintenance costs include indirect and direct funded supplies, maintenance, and repair contracts, and a portion of indirect funded Plant Engineering Department salaries.

FY2002 maintenance funding is at about the same level as FY2001. The current value of our deferred maintenance is $17.5M.

Site and Facilities 10-Year Plan

Plans and budgets are being developed for the accelerator energy upgrade to 12 GeV. This effort will involve significant machine alterations and civil construction including a new experimental hall, expansion of the CHL building, a technical support building, and other facilities to support the increased energy operations. An addition to the FEL building is currently being planned and budgeted. This addition, when complete, will house HELIOS, lithophotography equipment, and additional research labs.

We are currently in the process of updating our Strategic Facilities Plan for FY2004-FY2013, which outlines facilities requirements over then next ten-year period. The plan identifies projects to maintain existing facilities, make energy savings alterations, provide office and technical space for staff per projections, eliminate substandard storage space and structures at the end of their useful life, and eliminate leases that do not lead to building ownership.

The immediate need is for a larger computing center and office space to replace inadequate office trailers and to support a growing number of program staff and users, storage to replace inadequate storage containers, technical space, and relocation of Shipping & Receiving. Among the remaining critical needs is a substantial upgrade in the capacity, redundancy, and monitoring of the HVAC for the accelerator and experimental hall areas. Roads and parking areas in the accelerator area need to be completed. Aging equipment in the older buildings on site require replacement to ensure reliability.

Site development continues to be guided by the area themes identified by Jefferson Lab's Site Development Plan, written in 1988, revised in 1993, and currently being updated. An important principle of this plan is to co-locate compatible functions and to reserve the maximum amount of space near the accelerator site for future additional end stations or technical facilities benefiting from proximity.

Capital Investment Requirements

Historically Jefferson Lab has been provided $300K annually in General Plant Project (GPP) funds. Beginning in FY 2002 the GPP funding level has increased to $500K annually. The GPP requirements have been identified in the Budget Submission for $965K in FY2003 and $4.7M in FY2004 for specific projects. The Laboratory is not allocated any General Plant Equipment funds.

Assets Management

Condition Assessment surveys are conducted for all facilities on a three year cycle by a cross functional team. In addition to looking at the specific condition of the facilities utilization of equipment, property, and space are also included. In addition, in conjunction with our annual inventory of sensitive property, management identifies excess equipment, which is processed for disposal.

The below indicated square feet of trailer space will become excess property as a result of completion of the indicated planned line item and GPP funded projects (Table VI-14).

CEBAF Center Addition Phase 1	(22,000 sq ft)
Technical Support Building	(9,000 sq ft)
Storage Building Phase 1	(10,000 sq ft)

Energy Management and Sustainable Design

Four projects have been identified and are in the final stages of planning under a Utility Incentive Program. In addition to the capital improvements that will result in energy savings, two of the projects will replace aging mechanical equipment more than 37 years old. The four projects are:

- Replace VARC HVAC
- Build a Central Chiller Plant to replace Test Lab and accelerator service buildings HVAC
- Upgrade CEBAF Center Controls
- Upgrade lighting in various buildings

Energy evaluations have been conducted on a number of our facilities and energy savings projects identified. The four projects listed above are the largest of the currently planned projects. Additional utility metering is being installed to allow tracking energy consumption at the building level. Funding availability is the factor limiting the level of efforts in this area. None of our buildings have currently achieved Energy Star status.

Jefferson Lab is incorporating sustainable design principles into our current operations and construction activities at several levels. The planning for all new construction projects is reviewed in the context of the National Environmental Policy Act process as to the impact of an action on the natural, human, and social environments. Designs include provisions for energy and life cycle cost goals. Construction that disturbs physical land requires submission of erosion control and safety/spill prevention plans by the construction subcontractor as appropriate for the project. A requirement for recycling specified products has been added to all new facility construction contracts. Hazardous waste management is prescribed in our Laboratory Environmental Health & Safety Manual.

Table VI-14
Facilities Plan Funding Needs FY2003-FY2013 (AY M$)

($ in Millions)	GPP Projects	Line Item Projects	Operating Expense Projects Including Rent	Indirect Funded Maint.
FY2003 Required	0.8	1.5	1.2	3.0
FY2004 Required	4.8	4.6	1.6	3.1
FY2005 Required	3.6	5.9	1.5	3.2
FY2006 Required	4.4	7.0	1.7	3.6
FY2007 Required	1.5	7.3	1.3	3.8
FY2008 Required	1.9	6.0	1.3	4.2
FY2009 Required	1.0		1.3	4.4
FY2010 Required	1.0		1.2	4.6
FY2011 Required	1.0		1.2	4.8
FY2012 Required	1.0		1.2	5.0
FY2013 Required	1.0		1.2	5.2
Total Facilities Plan	**22.0**	**32.3**	**14.7**	**44.9**

Note: This chart includes facilities that are or are being requested to be funded by DOE. Details of the GPP and Line Item Projects are in Appendix B of the institutional plan.

Figure VI-5 Site Plan

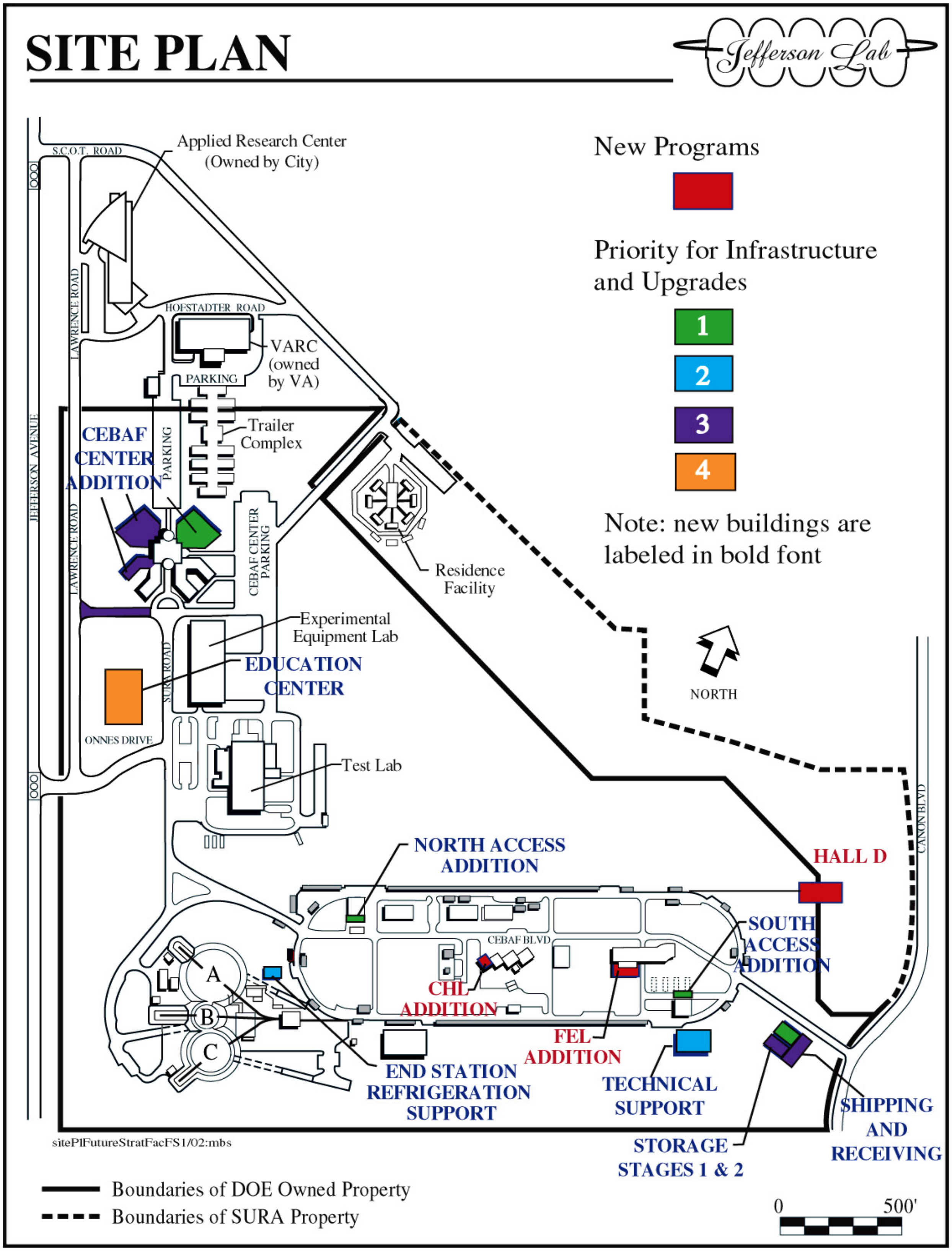


Table VI-15
Laboratory Space Distribution

Location	Area (Sq. Ft.)
Main Site	621,089
Leased -Off Site	54,872
	675,961

Table VI-16
Facilities Replacement Value (FY02 M$)

Facility Type	Replacement Value
Buildings	203
Utilities/Roadways	12
Accelerator Technical Systems	315
Experimental Equipment	197
TOTAL	727

Figure VI-6
Age of Laboratory Buildings (Years)

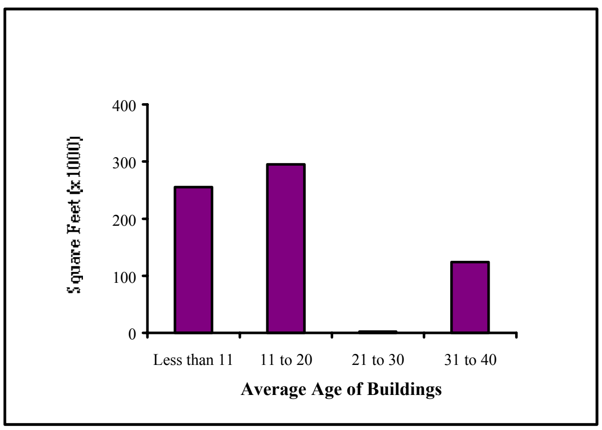


Figure VI-7
Condition of Laboratory Space

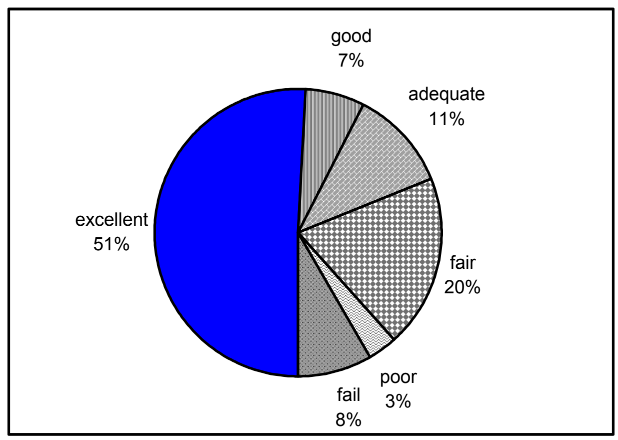
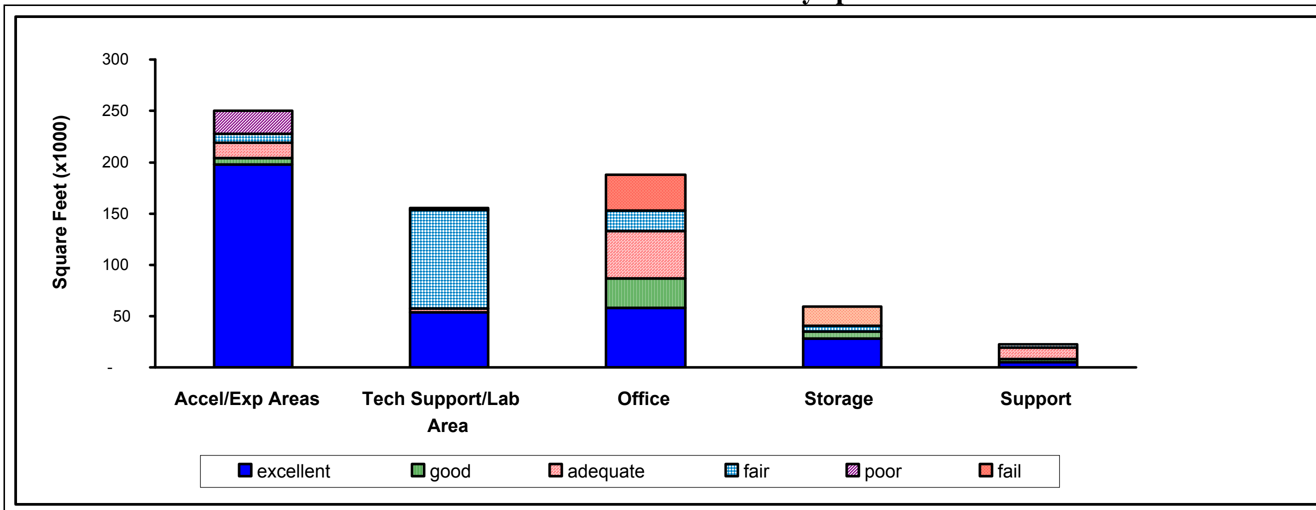


Figure VI-8
Use and Condition of Laboratory space



VII. MAJOR ISSUES

Issue 1 – Operations Support for our Research and Facilities to Remain at the Forefront

Jefferson Lab has received budgets for several years that are insufficient to compensate for the effects of inflation. The cumulative effects of this funding pattern have begun to adversely impact a number of critical areas. The need for adequate funding of new and unique advanced facilities has been recognized as the first priority recommendation in the 2001 NSAC Long Range Plan, which noted that

"The highest priority of the nuclear science community is to exploit the extraordinary opportunities for scientific discoveries made possible by these investments. Increased funding for research and facility operations is essential to realize these opportunities."

At Jefferson Lab increased funding is needed for the following mission-critical priorities:

Increasing Physics Productivity

A priority at Jefferson Lab is to maximize the research productivity of the Laboratory by making its unique capabilities available to users. As responsible stewards of the federal investment in Jefferson Lab, we emphasize increasing the physics output and reducing the backlog of experiments. Funding identified in our requirements budget allows an increase in physics productivity by ~43% over FY02. Strengthening the Laboratory's scientific leadership in its core competency areas of experimental and theoretical nuclear physics also would be addressed with adequate operations funding.

Strengthening Capabilities in High Performance Computing and LQCD

Jefferson Lab has several unique opportunities to build on its underlying theory program by working with other laboratories and universities to develop high performance computing and LQCD calculations, adding a new dimension to our physics capabilities.

Maintaining and Strengthening Core Competencies to Benefit the Larger Scientific Community

Jefferson Lab has unparalleled expertise in several areas of Accelerator Physics and Technology. However, funding has not been sufficient to build upon and advance this expertise. In fact, without sufficient funding, this core competency will begin to erode, and we will lose expertise beneficial not only to our program at Jefferson Lab, but to the larger scientific community. Additional funding would allow Jefferson Lab to build on this core competency to bring revolutionary gains in SRF and related technologies that would benefit many DOE science programs.

Issue 2 – The Path Forward to a Timely Start of the 12 GeV Upgrade

The science programs associated with the energy upgrade of CEBAF have been strongly endorsed by the DOE/NSF NSAC Long Range Planning Group. NSAC's new (2001) Long Range Plan includes as one of its principle recommendations:

"We strongly recommend the upgrade of CEBAF at Jefferson Laboratory to 12 GeV as soon as possible. The 12 GeV upgrade of the unique CEBAF facility is critical for our continued leadership in the experimental study of hadronic matter. This upgrade will provide new insights into the structure of the nucleon, the transition between the hadronic and quark/gluon description of matter, and the nature of quark confinement."

Jefferson Lab would like authorization (CD-0) and funding to carry out the necessary R&D, design work and prototyping to pursue the earliest possible start for the project. Approval of CD-0 will allow us to proceed with a detailed Conceptual Design Report, and pursue multinational partners and other funding agencies to provide vital equipment for the project. Foreign partners in particular will not commit resources until they are assured that a project has a high probability of proceeding.

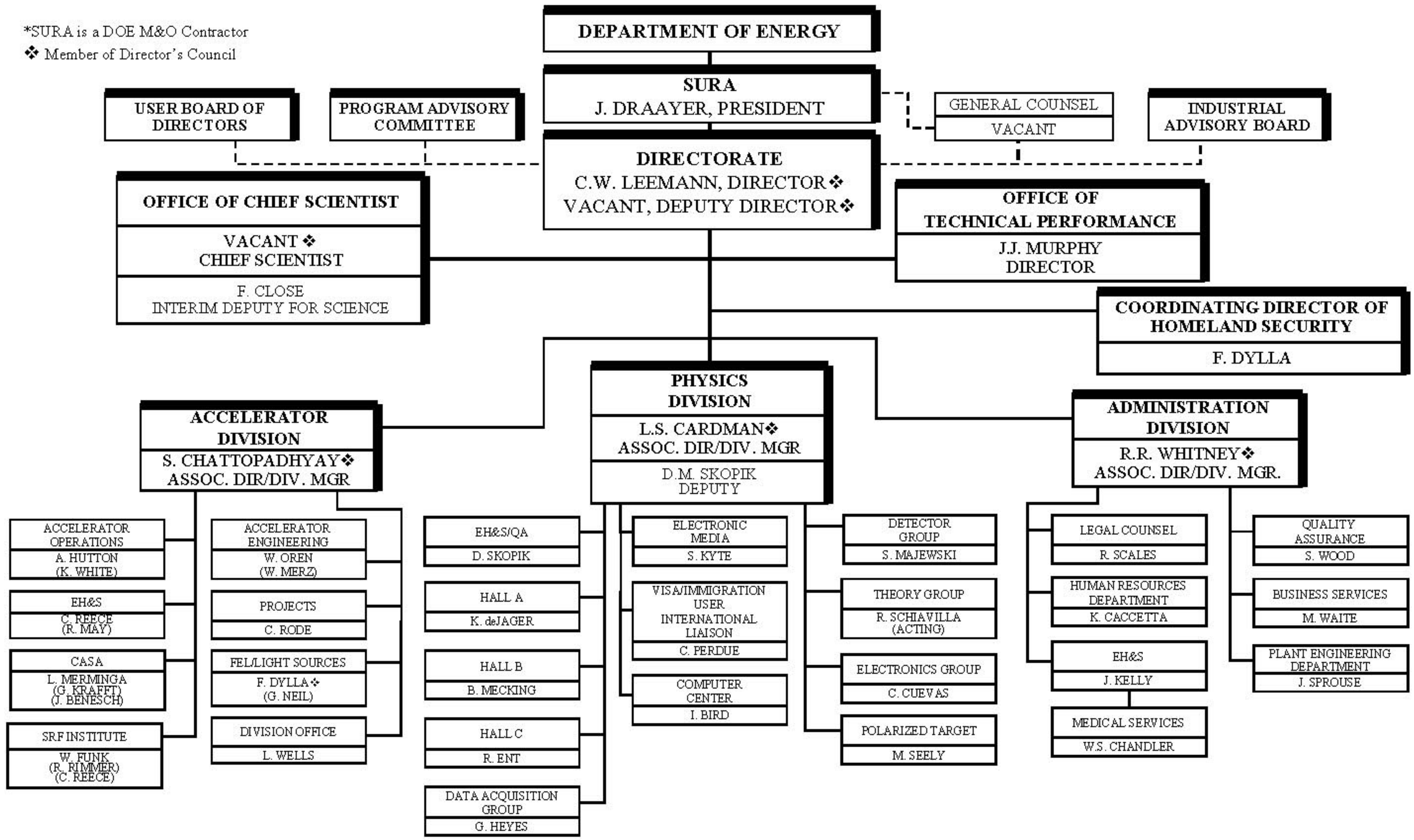
DOE's commitment to the 12 GeV upgrade (CD-0) is also very important to the user community that has worked enthusiastically to develop the scientific White Paper and contributions to the Long Range Planning process. This community will work to obtain support from collaborators here and abroad in pursuit of the science they envision from the upgrade. Another time consideration for a funding profile that begins PED activities in FY2004 is that we can coordinate in a cost-effective manner the trained manpower that we have acquired via our work supporting the SNS. If the project remains on its timetable, synergy exists between the ramp down of SNS-related work and the ramp up of the upgrade effort. If such coordination is not possible, we will surely lose this important resource, resulting in both time and cost impacts to the upgrade.

Issue 3 – Identify and Establish a Source of Stable Operations Funding for the Jefferson Lab FEL

The Jefferson Lab FEL has made real contributions, both as a test bed for advanced accelerator technologies and as a scientific tool. We have leveraged Commonwealth of Virginia and other resources to allow operating time for selected high profile experiments. The output of these experiments is outstanding, and the clear potential exists for the FEL to grow into user facility with worldwide unique capabilities for basic and applied research. It is an institutional priority to identify and secure a stable operations funding source for the FEL to realize its potential for Jefferson Lab and the nation.

APPENDIX A: SURA*/JEFFERSON LAB ORGANIZATION

*SURA is a DOE M&O Contractor
❖ Member of Director's Council



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Appendix B
Facilities and Infrastructure Plan

Strategic Facilities Plan (Requirements Budget for FY2003 - FY2013)	Project Number	SF	FY 2002 Approp. ($000)	FY 2003 ($000)	FY 2004 ($000)	FY 2005 ($000)	FY 2006 ($000)	FY 2007 ($000)	FY 2008 ($000)	FY 2009 ($000)	FY 2010 ($000)	FY 2011 ($000)	FY 2012 ($000)	FY 2013 ($000)
SITE NAME: Jefferson Lab														
1.0 Line Item Projects														
CEBAF Center Addition, Phase 1 (TJNAF)	MEL-001-033	59,000		1,500	4,600	4,400								
CEBAF Center Addition, Phase 2 (TJNAF)		71,000				1,500	7,000	6,500						
Test Lab Rehab								800	6,000					
Subtotal line Item Projects		**130,000**		1,500	4,600	5,900	7,000	7,300	6,000	-	-	-	-	-
2.0 General Plant Project (GPP)														
Acid Neutralization Building	02-GPP-300-1	320	120											
End Station Emergency Generator	02-GPP-300-2	-	170											
Miscellaneous Projects	02-GPP-300-3	-	270											
Computer Center AC/Power (LQCD)	03-GPP-300-1			175										
Site Storm Drainage Improvements	03-GPP-300-2	-		105										
Service Building A/C Controls	03-GPP-300-3	-		65										
Site Utilities Infrastructure	03-GPP-300-4	-		160										
LQCD Computing Space	03-GPP-300-5	1,000		150	200									
Miscellaneous Projects	03-GPP-300-6	-		110										
Test Lab Fire Protection improvements	04-GPP-300-1	-			50									
Upgrade Accelerator Fire Detection Zones	04-GPP-300-2	-			55	90	125							
Site Storm Water Drainage Improvements	04-GPP-300-3	-			120									
Site Utilities Infrastructure	04-GPP-300-4	-			25	100	140	150						
Miscellaneous Projects	04-GPP-300-5	-			110									
Technical Support Building	04-GPP-300-6	16,000			2,000									
North/South Access Additions	04-GPP-300-7	3,000			520									
Storage Building (Phase 1)	04-GPP-300-8	14,000			1,070									
Digital microwave& Laser-optics R&D Lab	04-GPP-300-9	3,000			600									
Rehab CEBAF Ctn Kitchen	05-GPP-300-1					500								
Additional Technical Labs (Relocate S&R)	05-GPP-300-2	5,000				965								
Storage Building (Phase 2)	05-GPP-300-3	10,000				1,000								
Site Lighting	05-GPP-300-4	-				200								
Miscellaneous Projects	05-GPP-300-5	-				110								
Refrigeration Service Building & Utilities	06-GPP-300-1	3,600				600	1,635							
Comms Ductbank Btw MCC & NLinac	06-GPP-300-2	-					120							
Rehab CEBAF Center HVAC	06-GPP-300-3						850	850	850					
Physics Technical Site Offices	06-GPP-300-4	4,000					600							
Miscellaneous Projects	06-GPP-300-5	-					115							
Rehab Counting House HVAC	07-GPP-300-1						800							
Miscellaneous Projects	07-GPP-300-2	-						500						
Miscellaneous Projects (FY2008-2013)		-							1,000	1,000	1,000	1,000	1,000	1,000
Subtotal GPP (ALL Nuclear Physics Funded)		**59,920**	560	765	4,750	3,565	4,385	1,500	1,850	1,000	1,000	1,000	1,000	1,000

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Strategic Facilities Plan (Requirements Budget for FY2003 - FY2013)	Project Number	SF	FY 2002 Approp. ($000)	FY 2003 ($000)	FY 2004 ($000)	FY 2005 ($000)	FY 2006 ($000)	FY 2007 ($000)	FY 2008 ($000)	FY 2009 ($000)	FY 2010 ($000)	FY 2011 ($000)	FY 2012 ($000)	FY 2013 ($000)
3.0 Non NP Projects														
FEL Test Cave		825		300										
FEL Addition		22,600		3,000	1,700									
Central Chiller Plant/ Service Bldg. HVAC		-	3,200											
Replace VARC HVAC		-	835											
Lighting Retrofit Various Bldg.		-	405											
Replace CEBAF Center HVAC Controls		-	140											
Education Center (BEAMS, etc.)		20,000				3,600								
Subtotal Non-Nuclear Physics Funded		43,425	4,580	3,300	1,700	3,600	-	-	-	-	-	-	-	-
4.0 Elimination of Excess	**Project Number**	**Excess SF Elimated**												
CEBAF Center Addition, Phase 1 (TJNAF)	MEL-001-033	22,000				75								
CEBAF Center Addition, Phase 2 (TJNAF)		15,200							50					
Technical Support Building (Excess existing trailers)	04-GPP-300-6	9,000				30								
Storage Building Phase 1 (Excess existing transportainers)	04-GPP-300-10	10,000				15								
Storage Building Phase 2 (Excess existing transportainers)		8,000						10						
Physic Trailers		2,000							5					
Subtotal of Area Eliminated		66,200				120		10	55					
5.0 Leased Space		**Leased SF**	**$**	$		$	$	$	$	$	$	$	$	$
ARC Building (Basic)		41,550	498	498	522	522	547	547	574	574	602	602	632	632
ARC Building (reduction)		(16,000)							(221)	(221)	(231)	(231)	(241)	(241)
ARC Building (RADCON)		842	18	18										
ARC Building (Conference Rm)		199	2	4										
Temp Office Lease (Phase 1)		20,000			360	360	360							
Blue Crab Warehouse		7,000	40	40	40	40	40	40	40	40				
Middleground Warehouse		3,380	30	30	30									
Hampton Crane & Rigging Warehouse		2,000	6											
Hampton Crane & Rigging Warehouse (80 SF)		80		1	1	1	1							
Temp Warehouse		10,000							60	60				
Federal Document Center			-	8	8	8	8	8						
Subtotal Leased Space		69,051	594	599	961	931	956	595	453	453	371	371	391	391

APPENDIX C: GLOSSARY OF JEFFERSON LAB ACRONYMS USED WITHIN INSTITUTIONAL PLAN

AIP	Accelerator Improvement Project
ALARA	As Low As Reasonably Achievable
ANL	Argonne National Laboratory
ARC	Applied Research Center
AY	Actual Year
BEAMS	Becoming Enthusiastic About Math and Science
BNL	Brookhaven National Lab
CASA	Center for Advanced Studies of Accelerators
CEBAF	Continuous Electron Beam Accelerator Facility
CD-0	Critical Decision 0
CHL	Central Helium Liquifier
CHROME	Cooperating Hampton Roads Organizations For Minorities in Engineering
CLAS	CEBAF Large Acceptance Spectrometer (Hall B)
CW	Continuous Wave
DESY	Deutsches Elektronen-Synchrotron
DOD	Department of Defense
DOE	Department of Energy
EH&S	Environment, Health, and Safety
EIC	Electron Ion Collider
ELFE	Electron Laboratory for Europe
e-RHIC	Electron-Relativistic Heavy Ion Collider
ERL	Energy Recovered Linac
FEL	Free-Electron Laser
FIU	Florida International University
FNAL	Fermi National Accelerator Laboratory
FY	Fiscal Year
GeV	Billion electron volts
GDH	Gerasimov-Drell-Hearn
GPP	General Plant Project
HBCU	Historically Black College or University
HELIOS	High Energy Lithography Source
HNSS	Hyper Nuclear Spectrometer System
HR&S	Human Resources and Services
HRIS	Human Resources Information Systems
HRS	High Resolution Spectrometer (Hall A)
HSI	Hispanic Serving Institutions
HUGS	Hampton University Graduate Studies
HVAC	Heating, Ventilation, Air Conditioning
IR	Infrared
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
ISRFST	Institute for Superconducting Radio-Frequency Science and Technology
JLab	Jefferson Lab
JLTRC	Jefferson Lab Technology Review Committee
JPIX	Jefferson Lab Picture Exchange
JTO	Joint Technology Office
LANL	Los Alamos National Laboratory
LPC	Laser Processing Consortium
LQCD	Lattice Quantum Chromodynamics

MIS	Management Information Systems
MIT	Massachusetts Institute of Technology
NAS	National Academy of Science
NASA	National Aeronautics and Space Administration
NCA&T	North Carolina Agricultural and Technical State University
NCCU	North Carolina Central University
NMSU	New Mexico State University
NP	Nuclear Physics
NRC	Nuclear Regulatory Commission
NSAC	Nuclear Science Advisory Committee
NSF	National Science Foundation
NSU	Norfolk State University
ONR	Office of Naval Research
ORNL	Oak Ridge National Laboratory
PAC	Program Advisory Committee
PPDG	Particle Physics Data Grid
PEST	Physics Enrichment for Science Teachers
PRIMEX	Primakoff Experiment
QA	Quality Assurance
QCD	Quantum Chromodynamics
R&D	Research and Development
Rf	Radio Frequency
RHIC	Relativistic Heavy Ion Collider
RIA	Rare Isotope Acceleration
RPP	Radiation Protection Program Plan
S&DB	Small and Disadvantaged Business
SCiDAC	Science's Discovery through Advanced Computing
SER	Site Environmental Report
SNS	Spallation Neutron Source
SRF	Superconducting Radio-Frequency
SUNBEAMS	Students United with NASA Become Enthusiastic About Math and Science
SURA	Southeastern Universities Research Association
TESLA	TeV – Energy Superconducting Linear Accelerator
TPC	Total Project Cost
UTEP	University of Texas at El Paso
UV	Ultraviolet
VARC	Virginia Associated Research Center
VLANs	Virtual Local Area Networks
WSS	Work Smart Standards